Catalogue 11-528E Occasional

Environmental Perspectives 1993

Studies and Statistics

75 Years of Excellence / Ans d'excellence

Statistics Canada Statistique Canada

Canada

Data in Many Forms . . .

Statistics Canada disseminates data in a variety of forms. In addition to publications, both standard and special tabulations are offered on computer print-outs, microfiche and microfilm, and magnetic tapes. Maps and other geographic reference materials are available for some types of data. Direct access to aggregated information is possible through CANSIM, Statistics Canada's machine-readable data base and retrieval system.

How to Obtain More Information

Inquiries about this publication and related statistics or services should be directed to:
System of National Accounts,
National Accounts and Environment Division,
Statistics Canada, Ottawa, K1A 0T6 (Telephone: 613-951-3765, Facsimile number: 613-951-3618) or to the Statistics Canada reference centre in:

St. John's	(772-4073)	Winnipeg	(983-4020)
Halifax	(426-5331)	Regina	(780-5405)
Montreal	(283-5725)	Edmonton	(495-3027)
Ottawa	(951-8116)	Calgary	(292-6717)
Toronto	(973-6586)	Vancouver	(666-3691)

Toll-free access is provided in all provinces and territories, **for users who reside outside the local dialing area** of any of the regional reference centres.

Newfoundland and Labrador	1-800-563-4255
Nova Scotia, New Brunswick and Prince Edward Island	1-800-565-7192
Quebec	1-800-361-2831
Ontario	1-800-263-1136
Manitoba	1-800-542-3404
Saskatchewan	1-800-667-7164
Alberta	1-800-282-3907
Southern Alberta	1-800-472-9708
British Columbia (South and Central)	1-800-663-1551
Yukon and Northern B.C. (area served by NorthwesTel Inc.)	Zenith 0-8913
Northwest Territories (area served by NorthwesTel Inc.)	Call collect 403-495-3028

How to order Publications

This and other Statistics Canada publications may be purchased from local authorized agents and other community bookstores, through the local Statistics Canada offices, or by mail order to Publication Sales, Statistics Canada, Ottawa, K1A 0T6.

Telephone Number 1-613-951-7277

Facsimile Number 1-613-951-1584

National toll free order line 1-800-267-6677

Toronto
Credit card only 1-416-973-8018

Statistics Canada
National Accounts and Environment Division
System of National Accounts

Environmental Perspectives 1993

Studies and Statistics

Years of Excellence Ans d'excellence

Published by authority of the Minister responsible for Statistics Canada

March 1993

Price: Canada $25.00
United States: US$30.00
Other Countries: US$35.00

Catalogue No. 11-528E

ISBN 0-660-14755-6

Ottawa

Version française de cette publication disponible sur demande (n° 11-528F au catalogue).

Note of Appreciation

Canada owes the success of its statistical system to a long-standing cooperation involving Statistics Canada, the citizens of Canada, its businesses and governments. Accurate and timely statistical information could not be produced without their continued cooperation and goodwill.

Printed on recycled paper.

Statistics Canada Statistique Canada

Canada

Canadian Cataloguing in Publication Data

Main entry under title:

Environmental perspectives, 1993 : studies and statistics

Issued also in French under title:
Perspectives environnementales, 1993 : études et statistiques.
ISBN 0-660-14755-6
CS11-528E

1. Environmental indicators -- Canada.
2. Environmental protection -- Canada.
3. Conservation of natural resources -- Canada.
I. Statistics Canada. National Accounts and Environment Division.
II. Statistics Canada. System of National Accounts Branch.
III. Title.

HC113.5 E58 1993 333.7'0971
C93-099317-9

Environmental Perspectives 1993

Studies and Statistics

Table of Contents

Technical Information

Symbols and Abbreviations

The following standard symbols are used in Statistics Canada publications:

..	figures not available
...	figures not appropriate or not applicable
—	nil or zero
- -	amount too small to be expressed
p	preliminary figures
r	revised figures
x	confidential to meet secrecy requirements of the Statistics Act

Prefixes of the International System of Units

prefix	Multiplication Factor	
peta	10^{15}	1 000 000 000 000 000
tera	10^{12}	1 000 000 000 000
giga	10^{9}	1 000 000 000
mega	10^{6}	1 000 000
kilo	10^{3}	1 000
hecto	10^{2}	100
deca	10^{1}	10
deci	10^{-1}	0.1
centi	10^{-2}	0.01
milli	10^{-3}	0.001
micro	10^{-6}	0.000001
nano	10^{-9}	0.000000001
pico	10^{-12}	0.000000000001

Energy Conversion Factors

1 barrel = .15891 cubic metres
1 ton = .9071847 metric tonnes

Fuel type	Natural unit	Multiplier
		terajoules
Coal: Anthracite	kilotonnes	29.53
Imported bituminous	kilotonnes	29.99
Canadian bituminous	kilotonnes	23.81
Sub-bituminous	kilotonnes	19.76
Lignite	kilotonnes	15.35
Coke	kilotonnes	28.83
Coke oven gas	gigalitres	18.61
Propane	megalitres	25.53
Butane	megalitres	28.62
Ethane	megalitres	18.36
Crude oil	megalitres	38.51
Still gas	megalitres	41.73
Motor gasoline	megalitres	34.66
Kerosene	megalitres	37.68
Diesel	megalitres	38.68
Light fuel oil	megalitres	38.68
Heavy fuel oil	megalitres	41.73
Petroleum coke	megalitres	42.38
Aviation gasoline	megalitres	33.52
Aviation turbo fuel	megalitres	35.93
Natural gas	gigalitres	37.97
Electricity	gigawatt hours	3.6
Steam	kilotonnes	2.75
Solid wood wastes	kilotonnes	18.00
Spent pulping liquor	kilotonnes	14.00

Abbreviations

1986$	1986 constant dollars
°C	degrees Celsius
cm	centimetre
ha	hectare
hr	hour
kg	kilogram
km	kilometre
km^2	square kilometres
kPa	kilopascals
kt	kilotonne
l	litre
m	metre
m3	cubic metre
MCm	million cubic metres
mg	milligram
mm	millimetre
Mt	megatonne
ng	nanogram
nec	not elsewhere classified
ppb	parts per billion
ppm	parts per million
SIC	Standard Industrial Classification
t	metric tonne
µg	microgram

Introduction

Understanding changes in environmental quality in Canada demands a wide variety of information to portray environmental change, its causes and its impacts. Physical and biological data, compiled by scientific, environmental and natural resource agencies, contribute to the evaluation of water, air, land and biotic resources. Social and economic data on population, agriculture, manufacturing, transportation and energy are essential in describing the role human activities play in the process of environmental change.

Environmental Perspectives: Studies and Statistics is a new publication for disseminating the results of surveys and data development projects related to the environment. It brings together data from a variety of sources including surveys undertaken by Statistics Canada, the agency's Environmental Information System, and other government and non-government databases. The publication will appear between issues of the quinquennial *Human Activity and the Environment* which was last published in 1991[1].

Whereas *Human Activity and the Environment* is a comprehensive compendium of environmental data, this publication should be seen more as a selection of data and analysis that reflect the progress of Statistics Canada in developing a more complete set of environmental accounts and underlying data bases. The topics covered in this volume have not been chosen to provide a balanced view of environmental conditions and related activities, but rather to fill perceived gaps in the environmental information system.

This edition of the publication covers five general themes. Chapters 1 through 4 relate to the impact of industrial activity on the environment. The first two chapters present newly developed data on energy use and greenhouse gas emissions. The third brings together economic and environmental data in a cross-sectional analysis of the pulp and paper industry. In Chapter 4, the movement of dangerous goods by truck and rail is examined. Information on interprovincial movements by class of material is presented along with statistics on accidents.

Chapters 5 and 6 analyze land use and soil conservation. Chapter 5 presents a case study on the changing use of land surrounding Riding Mountain National Park in Manitoba. More intensive land use around the park brings increased stress on park wildlife that use the surrounding area as part of their range. Chapter 6 contains results on soil conservation practices from the 1991 Census of Agriculture. Data on the prevention of soil erosion are presented on a provincial basis.

Chapter 7 combines data from the new Household Environment Survey with family expenditure information to provide an insight into environmental behaviour of households. Data pertaining to mode of travel to work, use of energy saving devices and many other practices having an environmental impact are examined in the context of various characteristics such as family income and dwelling type.

Chapters 8 through 12 deal with four new surveys related to recycling and pollution abatement. Chapter 8 presents pollution abatement and control expenditures by industry for 1989 as well as a six-year perspective on pollution abatement expenditures relative to total capital spending. Chapter 9 examines the 1990 survey of industrial packaging undertaken to provide benchmark data for the National Packaging Protocol which seeks to reduce packaging sent to disposal to 50% of the 1988 level by the year 2000. Waste management is examined from the perspective of private contractors and local governments in Chapters 10 and 11 respectively. The results of the initial survey of private waste management reported in Chapter 10 depict a $1 billion industry in 1989. Tables show financial data by province and firm size. Chapter 11 provides a preliminary look at the characteristics of waste management by local governments and the division of responsibilities for collection, disposal and recycling for those municipalities with a population greater than 50 000. Information is presented on recycling and hazardous waste programs as well as other aspects of waste management. Chapter 12 examines the prices of selected scrap and virgin materials in order to describe their respective behaviour in changing markets.

Finally, Chapter 13 reports on developmental work on resource accounting for oil and gas. Different valuation methods are compared and a series of estimates are provided for oil and gas reserves according to several assumptions about future prices and costs.

1. The next issue of *Human Activity and the Environment* will appear in 1994 in order to provide more timely data from the quinquennial Censuses of Population and Agriculture.

Acknowledgements

This publication was prepared by the National Accounts and Environment Division, Philip Smith, Director and Kirk Hamilton, Assistant Director. The book was edited by Craig Gaston and major contributions to the overall content and presentation were made by Gylliane Gervais, Robert Smith and Hélène Trépanier. The authors were as follows:

Alice Born
Craig Gaston
Alan Goodall
Kirk Hamilton
Marcia Santiago
Robert Smith
Douglas Trant

Michael Bordt, Jacques Delisle, Phillip Fong, Jeff Fritzsche, Yvan Gervais, Bruce Mitchell, Michel Pascal, René Piché, Philippe Rhul, Michel Vallières, Sylvain Venne and Robert Loggie all provided valuable advice. The authors are also indebted to Mitzi Ross as marketing coordinator and advisor, and Susie Boyd for technical help.

1 Energy Consumption

by Kirk Hamilton

Energy in general, and fossil fuel in particular, plays an important role in the interaction between human activities and the environment. Each stage in the production, transport, refining, transformation and consumption of energy commodities has actual or potential consequences for the state and quality of the environment.

The production of energy commodities often requires gross physical changes in the environment, in the form of open-pit mines for coal or oil sands, or flooding of large areas to provide reservoirs for hydro-electricity. The transport systems for these commodities may entail physical changes such as above-ground pipelines, or may produce undesirable side-effects such as spills. Refining of energy commodities carries with it the risk of emissions of noxious or poisonous substances to the environment. And their transformation (for example, burning fossil fuels or the fission of nuclear materials to produce electricity) and consumption produces a full range of possible environmental consequences: release of noxious substances, emissions of oxides of carbon, sulphur and nitrogen, and accumulations of solid wastes requiring disposal.

As a result of energy conservation policies and rapid price increases until 1986, the efficiency with which energy is used has changed considerably in recent years. An aggregate indicator of this change is the primary energy/GDP ratio, which declined from 17.3 megajoules (MJ) per constant 1986 dollar in 1981 to 15.5 MJ per dollar in 1986, a fall of over 10% (Statistics Canada, 1991). This study aims to characterize energy use in Canada and to examine the macro-level changes that determine the overall efficiency of energy use.

To explore key aspects of the relationship between energy use and economic activity, detailed energy disposition accounts have been developed as part of the new National Accounts Environmental Component at Statistics Canada. These energy accounts measure the use of 9 major types of energy (coal, crude oil, natural gas, fuel oil, aviation gasoline, motor gasoline, liquefied petroleum gases, electricity and coke) for each of the 216 producing industries and 136 categories of final demand employed in the national input-output accounts (Statistics Canada, 1992a). A summary of the distribution of energy consumption by broad categories, based on these accounts, is shown in Table 1.

Table 1: Distribution of Energy Consumption

Sector	1971		1986	
	petajoules	percent	petajoules	percent
Business (excl. transport)	2 737	52.4	3 199	53.3
Transport	931	17.8	1 139	19.0
Household	1 551	29.7	1 654	27.6
Total	**5 219**	**100.0**	**5 992**	**100.0**

Source:
Statistics Canada, Industry Division.

The organization of energy data in Table 1 requires some explanation. Household energy includes that consumed in rented dwellings. Transport energy use includes for-hire transportation industries and energy for the operation of private vehicles, but excludes energy used for own-account transport (e.g. delivery vans) in the business sector. Business energy use spans all energy used in agriculture, mining, manufacturing and services, but excludes energy converted from one form to another (e.g. coal to electricity) and energy products used as feedstocks. In this accounting scheme, use of own product by energy producers is included in energy use. Table 1 sums to total private energy consumption.

Table 1 shows that household energy use as a proportion of the total declined by 2% between 1971 and 1986, because of stronger growth in the energy used in the business sector and transport. Energy use in the business sector is highly concentrated, as seen in Table 2. In 1986 the five largest energy using industries accounted for 31% of total business sector energy use.

Table 2: Large Industrial Energy Consumers, 1986

Industry	petajoules
Pulp and paper	344
Iron and steel	216
Non-ferrous metals	175
Industrial chemicals	148
Petroleum refineries	114
Total	**997**

Source:
Statistics Canada, Industry Division.

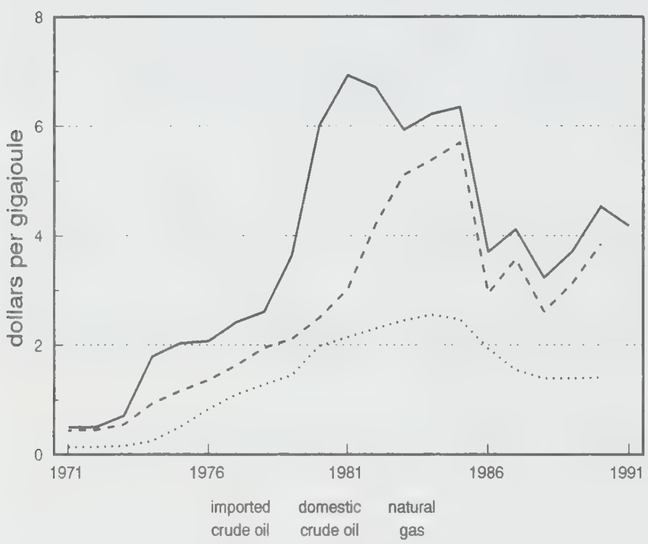
PRICES

Price is an obvious determinant of the demand for energy. It is worth examining two levels of prices. One is the international and domestic price for crude oil, the former reflecting worldwide demand and scarcity (or cartel pricing in the case of crude oil) and the latter reflecting this as well as domestic energy policy. The second is the price paid by Canadian residential consumers for delivered energy commodities, which reflects local market conditions as well as taxes. In Figures 1 and 2 these prices are expressed in dol-

lars per gigajoules so that they can be compared on a common basis of the energy content of the commodity.

As can be seen in Figure 1, crude oil prices have varied widely since the first OPEC oil shock in 1973. This figure compares imported crude oil, domestic crude oil and domestic natural gas prices. The striking feature of Canadian energy policy prior to 1984 was the establishment of a crude oil price substantially lower than the world price. These prices converged in 1984, but are not exactly equal because Figure 1 compares a domestic price that is weighted towards the well-head price in Alberta with the delivered price (including freight) of imported crude in Montreal. Natural gas prices at the field gate generally tracked the trends in crude oil prices but at a significantly lower level per unit of energy.

Figure 1: Crude Oil and Natural Gas Prices, 1971-1991

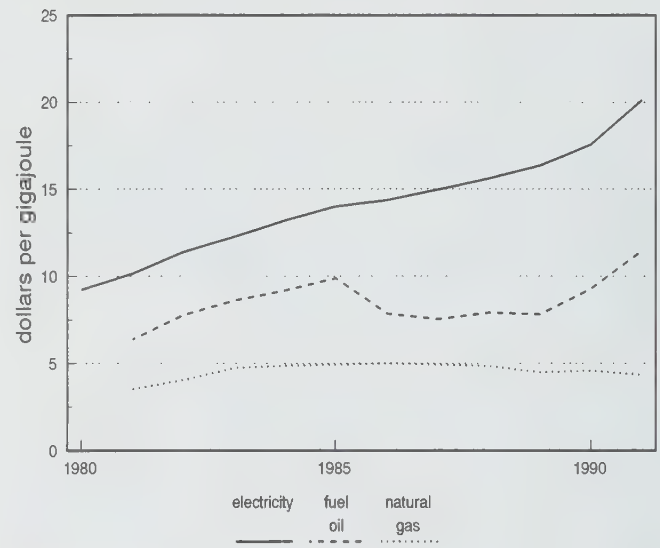


Source:
Canadian Petroleum Association, 1990.

Figure 2 compares the per-gigajoule prices (including taxes) of electricity, fuel oil and natural gas sold to households over the period 1980-1991. Electricity showed a steady increase in price over this period, whereas natural gas displayed both the lowest level and a virtually constant price. Fuel oil prices were much more erratic, falling sharply in 1986 (in step with crude oil prices), levelling off, then increasing in 1990 and 1991. It is noteworthy that electricity prices reached a level roughly 5 times those of natural gas by 1991.

While Figures 1 and 2 display current or nominal prices, the movement of energy prices relative to other prices is also of interest. Table 3 shows the nominal prices of imported crude oil and residential electricity and fuel oil, for 1981 as well as 1991. In addition, this table shows the movement in each of these prices relative to other prices since 1981. Over this decade, the price of imported crude oil declined substantially relative to other prices, while that of electricity showed a significant relative increase.

Figure 2: Residential Energy Prices, 1980-1991



Source:
Statistics Canada, 1992b.

Table 3: Energy Prices and Indices

Commodity	1981	1991	1991
	dollars per gigajoule		index
Imported crude oil	6.93	4.18	0.41
Residential electricity	10.14	20.11	1.23
Residential fuel oil	6.36	11.45	1.12

Note:
The index is relative to changes in the general price level since 1981. In the case of crude oil the GDP implicit price index is used to measure the price level, while for the residential energy prices the consumer price index, excluding energy and food, is used. For example, an index of 1.0 for imported crude oil would indicate that imported crude prices moved at the same rate as the general price level from 1981 to 1991.
Source:
Statistics Canada, Industry Division.

ENERGY INTENSITY OF BASIC MATERIALS

The energy intensiveness of a good or service is the total energy required in production directly (in the producing sector) and indirectly (by the producers of the inputs to the producing sector) per unit of output. For example, the energy intensity of an automobile consists of the energy consumed on the production line plus the energy required to make the steel, rubber, plastic and other component materials making up a car, divided by the dollar value of the car - this gives a measure in joules of energy per dollar of product. The data in the energy flow accounts and the input-output accounts to which they are linked permit straightforward energy intensity calculations (see, for instance, Hamilton, 1988).

By combining energy intensity in joules per dollar with producer prices it is possible to estimate direct and indirect energy requirements per physical unit of product. This is a particularly useful way to examine the changing energy intensiveness of basic materials over time. Because so much of buildings, other infrastructure and manufactured products are made up of lumber, steel, non-ferrous metals, paper products and cement, the energy intensiveness of these basic materials has a profound influence on the requirements for energy in the economy as a whole. Table 4 presents the estimated energy intensity of these products in 1971, 1981 and 1986.

Table 4: Energy Intensity of Basic Materials

Material	1971	1981	1986	Decrease 1971-86
	megajoules per tonne			percent
Lumber	1 554	1 669	1 454	6.4
Pulp and paper	24 215	20 921	17 329	28.4
Iron and steel	23 430	22 035	18 711	20.1
Non-ferrous metal	..	26 757	20 424	23.7
Cement	6 567	5 045	4 373	33.4

Source:
Statistics Canada, National Accounts and Environment Division.

The figures in Table 4 and subsequent tables measure total use of energy commodities, exclusive of the amounts used as feedstocks or converted into other forms of energy (e.g. when burning coal to produce thermal electricity). Imported products used as inputs into the production of these materials are assumed to have the same energy intensity as if they were produced in Canada. The figures therefore represent a pure measure of the energy required along the chain of production from extraction or harvest to final product.

When the materials are heterogeneous, changes in the product mix of the producing sector may influence the estimation of energy intensity[1]. Classification changes did not permit estimation of the energy intensity of non-ferrous metals in 1971, and so the percentage decrease shown in Table 4 for this material is from 1981 to 1986.

What emerges from this table is a striking drop in energy intensity for basic materials. Lumber shows an anomalous rise in 1981. However, lumber is generally low in energy intensity, and few opportunities exist for energy conservation in its production because it is a relatively unprocessed raw material. Pulp and paper and cement show substantial declines in energy intensity, while metals declined more moderately (although this is a fall over 5 years rather than 15 in the case of non-ferrous metals).

1. For example, carbon steel sheets increased from 21% to 31% of the constant dollar value of output of iron and steel from 1971 to 1986. Copper dropped from 25% to 14% of the constant dollar value of output of non-ferrous metals from 1981 to 1986.

ENERGY INTENSITY OF FINAL EXPENDITURE

Another useful way to summarize energy intensiveness and its change over time is to examine the energy intensiveness of the different categories of final expenditure. This is shown in Table 5.

Table 5: Energy Intensity of Final Expenditure, 1981-1986

Category	1981	1982	1983	1984	1985	1986
	megajoules per constant 1981 dollar					
Consumer expenditure	10.1	9.8	10.0	9.3	10.0	9.8
Investment in fixed capital	12.7	11.5	11.7	10.9	11.5	10.9
Government current expenditure	3.9	3.8	3.9	3.7	4.0	3.9
Exports	21.5	19.4	20.0	18.1	18.3	17.7
Imports	17.9	16.8	18.7	16.0	16.9	16.2

Source:
Statistics Canada, National Accounts and Environment Division.

It must be emphasized that this table presents not the energy consumed directly by (for instance) households, but rather the energy required to produce one dollar's worth of the whole spectrum of goods and services consumed by households. The energy consumed directly by households was shown in Table 1.

These figures reveal a consistent ranking of energy intensiveness by category of expenditure, with exports leading, followed closely by imports, then investment in fixed capital, consumer expenditure, and far behind, government current expenditure (which is largely wages and salaries and so does not entail significant energy use).

Notable declines in energy intensity from 1981 to 1986 include one of 14% for investment in fixed capital, 18% for exports and 10% for imports. The energy intensity of exports decreased by about 3.5% per year over this period, echoing the declines in energy intensiveness of basic materials measured earlier.

Some explanation is required for the row labelled "imports" in Table 5. The values reported in this row do not represent the actual energy intensities of our imports but rather, the energy intensities of these goods as if they were produced in Canada. The assumption implicit in these estimates is that foreign industries are exactly as energy intensive in the production of a particular commodity as are Canadian industries.

The results in Table 5 indicate that Canadian exports were approximately 20% more energy intensive than imports in 1981. By 1986 this gap had shrunk to 9%. Dollar

Table 6: Direct Energy Intensity by Industry, 1981-1986

Industry	1981	1982	1983	1984	1985	1986	1986	Annual change
	megajoules per constant 1981 dollar of output						rank	percent
1 Agriculture	8.1	7.4	10.5	7.3	7.5	7.2	14	-4.6
2 Fishing and trapping	19.6	19.6	17.7	20.3	16.6	15.9	6	-3.5
3 Logging and forestry	6.6	5.4	5.3	4.4	5.5	6.7	15	...
4 Mining	16.4	14.4	15.9	14.2	14.3	14.1	8	-3.5
5 Crude oil and natural gas	2.1	1.9	2.2	2.0	2.1	2.2	37	...
6 Quarries and sand pits	13.0	16.3	12.8	11.8	11.5	12.1	9	-2.1
7 Service related to mineral extraction	10.5	10.5	9.4	9.6	9.8	9.7	11	-1.2
8 Food processing	3.1	3.2	3.0	2.9	3.5	3.8	28	3.9
9 Beverages	5.7	5.6	5.0	4.8	5.7	5.9	21	...
10 Tobacco products	1.0	1.1	1.1	1.1	1.5	1.5	44	8.7
11 Rubber products	5.2	3.7	4.9	4.5	5.0	5.3	24	...
12 Plastic products	3.2	3.4	3.1	3.0	3.3	3.4	30	...
13 Leather products	1.7	1.7	1.8	1.9	2.6	2.4	36	8.8
14 Textiles	6.6	6.5	5.9	6.0	6.1	6.0	19	-1.7
15 Clothing	0.9	0.9	1.0	1.0	1.3	1.3	45	8.3
16 Wood products	5.2	5.5	5.0	4.9	4.6	4.2	26	-3.9
17 Furniture	2.0	2.5	2.2	2.2	3.1	2.8	32	8.1
18 Paper products	23.8	18.1	22.2	22.0	21.3	20.6	4	-2.7
19 Printing and publishing	1.1	1.2	1.2	1.1	1.5	1.6	42	8.0
20 Primary metals	25.4	26.1	24.9	21.7	23.3	22.7	3	-2.6
21 Fabricated metals	2.8	3.0	3.1	3.3	3.7	3.8	29	6.6
22 Machinery	1.9	2.5	2.4	2.3	2.8	2.6	33	6.4
23 Transport equipment	1.8	1.9	1.7	1.5	1.9	2.0	38	...
24 Electrical products	1.8	2.1	1.6	1.5	1.8	1.7	41	...
25 Non-metallic mineral products	25.6	26.0	23.8	23.7	24.2	24.8	2	...
26 Refined petroleum products	7.5	8.2	7.9	7.9	8.1	6.6	17	...
27 Chemical products	16.0	16.9	17.4	15.3	14.9	14.2	7	-3.0
28 Other manufacturing	1.9	1.9	1.8	1.8	2.3	2.6	34	6.3
29 Construction	2.1	2.0	1.8	1.9	1.9	1.8	40	-2.1
30 Transport	19.2	18.0	18.5	17.4	17.7	17.4	5	-2.1
31 Pipeline transport	42.4	37.7	27.4	34.4	41.8	36.0	1	...
32 Storage	6.0	6.3	5.4	7.8	8.3	7.6	12	8.1
33 Communication	2.1	2.2	1.9	1.9	2.1	1.8	39	...
34 Electric power and other utilities	11.4	12.8	12.4	11.7	12.3	12.0	10	...
35 Wholesale trade	5.4	5.3	4.7	4.9	4.7	4.1	27	-4.2
36 Retail trade	6.1	6.4	5.7	5.9	6.3	6.0	20	...
37 Finance and real estate	6.0	7.0	6.8	6.2	7.4	7.3	13	4.1
38 Insurance	1.3	1.1	0.9	0.7	0.7	0.7	46	-13.3
39 Government royalties on resources	-	-	-	-	-	-	47	-
40 Owner occupied dwellings	-	-	-	-	-	-	49	-
41 Business services	1.5	1.4	1.4	1.4	1.6	1.6	43	...
42 Educational services	5.9	6.1	5.5	5.9	7.4	6.6	16	4.2
43 Health services	2.7	2.8	2.4	2.7	2.6	2.6	35	...
44 Accommodation and food	6.0	6.3	6.0	6.5	7.1	6.6	18	3.0
45 Amusement and recreation	3.5	3.7	3.4	3.2	3.4	3.3	31	-1.0
46 Personal services	6.1	6.0	5.1	4.9	4.7	4.8	25	-4.9
47 Other services	4.5	4.6	4.5	5.0	5.3	5.3	23	4.0
48 Operating supplies	-	-	-	-	-	-	48	-
49 Travel, advertising and promotion	7.2	6.6	6.3	6.7	5.8	5.7	22	-4.4
50 Transport margins	-	-	-	-	-	-	50	-

Note:
Industries 48, 49 and 50 are fictive industries used for estimating the use of groups of commodities whose precise content is unknown.
Source:
Statistics Canada, National Accounts and Environment Division.

for dollar, therefore, Canada was a significant net exporter of energy embodied in the goods and services it traded.

DIRECT ENERGY INTENSITY BY INDUSTRY

Underlying the energy intensities presented in the preceding sections is the energy use per dollar of output of each of the 216 industries comprising the business sector of the input-output accounts. These direct energy intensities are presented for the years 1981 to 1986 at the level of 50 industries (see Table 6).

Although this table shows the rank of industries by energy intensiveness only for 1986, the ranking is remarkably stable over the years shown. Pipeline transport, with its high energy input and low value of output, ranks first, followed by the non-metallic mineral products industry (whose energy use is dominated by cement producers). These are followed in the top 5 by primary metals, paper products and the transport industry.

The annual changes in industry direct energy intensiveness were calculated over this period. Only those industries showing a significant trend appear in Table 6. While there are many instances of positive change (i.e. increasing energy intensiveness), these occur only for industries ranked very low in energy intensiveness. The majority

Table 7: Fuel and Electricity Shares by Industry, 1986

Industry	Coal	Natural Gas	Gasoline	Fuel oil	LPG	Electricity	Coke	Total
	percent							terajoules
1 Agriculture	1.7	10.3	29.2	37.5	3.1	18.2	--	179 243
2 Fishing and trapping	--	2.7	46.8	49.9	--	0.6	--	16 704
3 Logging and forestry	--	1.1	17.6	79.3	0.7	1.3	--	37 688
4 Mining	4.6	25.1	0.9	29.2	2.0	36.1	2.0	152 067
5 Crude oil and natural gas	--	19.4	20.2	7.5	5.9	47.0	--	47 015
6 Quarries and sand pits	--	10.9	7.0	67.2	--	14.7	--	10 621
7 Service related to mineral extraction	--	13.4	24.6	46.9	--	15.1	--	30 362
8 Food processing	--	70.6	4.1	9.9	1.2	14.0	--	114 441
9 Beverages	--	79.2	3.9	x	x	10.3	--	23 526
10 Tobacco products	--	x	x	x	x	25.4	--	1 770
11 Rubber products	x	67.7	x	x	0.6	21.0	--	12 816
12 Plastic products	x	54.1	2.2	3.8	x	38.7	--	12 562
13 Leather products	x	x	x	x	x	21.6	--	2 825
14 Textiles	x	x	0.6	x	0.6	17.6	--	32 082
15 Clothing	--	59.5	x	7.0	x	27.8	--	7 190
16 Wood products	--	42.1	4.0	16.9	2.3	34.6	--	44 321
17 Furniture	x	68.5	3.7	5.1	x	21.3	--	8 962
18 Paper products	x	26.4	0.1	20.8	0.2	50.6	x	358 294
19 Printing and publishing	--	60.4	5.0	2.6	2.0	30.0	--	12 680
20 Primary metals	2.5	26.5	x	x	0.2	38.1	28.6	420 190
21 Fabricated metal	--	76.6	2.7	3.2	1.7	15.8	--	48 451
22 Machinery	x	72.3	3.7	3.5	x	19.2	x	17 565
23 Transport equipment	x	x	x	x	x	20.4	x	68 253
24 Electrical products	x	x	x	x	x	26.7	x	25 379
25 Non-metallic minerals	18.6	x	0.6	7.6	0.7	11.1	1.7	129 473
26 Refined petroleum	x	41.1	x	x	0.4	12.3	x	113 529
27 Chemical products	x	68.7	x	3.8	0.5	25.9	x	242 535
28 Other manufacturing	--	69.7	x	x	x	20.9	--	12 309
29 Construction	x	x	60.0	29.8	2.4	3.9	--	105 298
30 Transport industry	0.1	5.2	10.7	79.1	2.1	2.8	--	497 737
31 Pipeline transport	x	92.9	--	1.1	x	6.0	--	84 349
32 Storage	--	17.9	6.9	56.7	2.8	15.8	--	6 713
33 Communication	--	18.7	28.8	26.9	4.3	21.3	--	24 879
34 Electric power and other utilities	--	7.3	6.9	0.7	0.2	84.9	--	164 023
35 Wholesale trade	x	13.9	54.9	14.8	4.2	11.9	x	118 028

Table 7: Fuel and Electricity Shares by Industry, 1986

Industry	Coal	Natural Gas	Gasoline	Fuel oil	LPG	Electricity	Coke	Total
	percent							terajoules
36 Retail trade	--	37.8	24.4	10.1	0.4	27.3	--	201 296
37 Finance and real estate	–	50.3	4.7	20.8	0.6	23.6	--	294 158
38 Insurance	–	24.4	19.8	20.9	2.2	32.6	--	4 370
39 Government royalties	--	--	--	--	--	--	--	--
40 Owner occupied dwellings	--	--	--	--	--	--	--	--
41 Business services	–	22.8	42.4	20.0	1.8	13.0	--	28 918
42 Educational services	x	55.1	x	14.8	--	29.1	--	7 395
43 Health services	x	19.2	30.1	35.5	x	12.9	--	22 068
44 Accommodation and food	–	47.6	1.3	23.9	0.7	26.5	--	95 703
45 Amusement and recreation	–	26.0	4.9	23.6	0.8	44.7	--	15 399
46 Personal services	–	10.8	12.2	52.2	2.7	22.1	--	19 837
47 Other services	--	16.1	52.7	19.2	1.5	10.6	--	30 173
48 Operating supplies	--	--	--	--	--	--	--	--
49 Travel, advertising and promotion	--	--	98.9	--	1.1	--	--	69 151
50 Transport margins	--	--	--	--	--	--	--	--

Note:
Industries 48, 49 and 50 are fictive industries used for estimating the use of groups of commodities where the precise commodity content is unknown.

of the most energy intensive industries showed declines between 2.1% and 3.5% per year.

FUEL AND ELECTRICITY SHARES BY INDUSTRY

The analysis to this point has concentrated on total use of energy and not on the fuels that constitute this total. Table 7 shows the percentage share of each type of energy in total use, by industry, in 1986. In total, the dominant energy type is natural gas with a share of nearly 33%, followed by electricity at roughly 25% and fuel oil at 24%.

Coal shows up as only 2.5% of energy use in the primary metals industry because most of it is converted to coke before use - coke in turn constitutes 28.6% of the energy used in this sector. Natural gas is the major energy input to pipeline transport, but is also important in beverages and fabricated metals. Gasoline is the dominant energy source in wholesale trade, to power fleets of delivery vehicles. Fuel oil, which includes diesel and aviation gasoline, is the chief energy source for the transport industry and logging and forestry. Finally, electricity is the major energy input to the paper products industry.

SUMMARY

The distribution of energy consumption across broad sectors has changed little since 1971, and the use of energy in the business sector remains highly concentrated in a few large industries. Crude oil and natural gas prices have been extremely volatile since 1973, while residential energy prices, particularly for electricity, have risen faster than the general price level since 1981. There is an overall trend towards increasing energy efficiency evident in the decreasing energy intensiveness of basic materials and in the direct use of energy per dollar of output in the major energy consuming industries. Among categories of final expenditure, exports, investment in fixed capital and imports, all showed marked declines in energy intensiveness from 1981 to 1986.

REFERENCES

Canadian Petroleum Association. *Statistical Handbook.* Calgary, 1990.

Hamilton, K.E. "Energy Intensiveness and Economic Performance Since 1971" in *Canadian Economic Observer*, 1: 12. Catalogue 11-010. Statistics Canada, Ottawa, 1988.

Statistics Canada. *Human Activity and the Environment 1991.* Catalogue 11-509, Ottawa, 1991.

----. *The Input-Output Structure of the Canadian Economy.* Catalogue 15-201, Ottawa, 1992a.

----. *Energy Statistics Handbook.* Catalogue 57-601, Ottawa, 1992b.

2 Canadian Greenhouse Gas Emissions: An Input-Output Study

by Robert Smith[1]

INTRODUCTION

Statistics Canada has recently initiated development of a set of accounts that will form an environmental component for the Canadian System of National Accounts. Four accounts will comprise this component: a natural resource stock account, a natural resource use account, a waste and pollutant output account and an environmental expenditure account.

The work presented below has been undertaken as a pilot study for the waste and pollutant output account. This account will integrate information on the types, quantities and destinations of waste material generated by economic activity into a framework based on the Canadian input-output tables published annually by Statistics Canada. In the present study information on the types and quantities of greenhouse gases released from Canadian production and consumption activity have been analyzed using an augmented version of the 1985 input-output tables (Statistics Canada, 1989). The general method for augmenting the input-output tables used here is based on the work of Victor (1972).[2]

Greenhouse gas emissions have been chosen for this pilot account for two reasons. First, greenhouse gas emissions are currently under scrutiny in Canada and elsewhere because of the likelihood that increased atmospheric concentrations of these gases will create an enhanced greenhouse effect (see below). The federal government, for its part, has committed Canada to the stabilization of greenhouse gas emissions at 1990 levels by 2 000 (Government of Canada, 1990). It is hoped that the work presented here will aid in the effort to meet this goal. Second, in contrast to many categories of waste emissions, a good deal of data are available for estimating greenhouse gas emissions. Thus, it is possible to present a very complete pilot account of these emissions.

1. The author would like to thank Patrick Adams for his work in developing the energy disposition tables that were used in this study.
2. Those readers interested in more details of input-output modelling and its use for environmental analysis are referred to the appendix at the end of this chapter. Details of the input-output model used in this study are available on request from the author.

THE GREENHOUSE EFFECT

The atmosphere surrounding the earth consists almost entirely of nitrogen and oxygen, with the remaining portion comprised of a variety of gases found in very low concentrations. A certain group of these trace gases are responsible for what has come to be known as the "greenhouse effect", which can be briefly explained as follows.

Short wave solar radiation passes relatively unhindered through the earth's atmosphere to the surface of the planet. Objects on the surface absorb this incoming radiation and are warmed. The warmed objects, in turn, re-emit longer wavelength (infrared) radiation back into the atmosphere. The atmosphere is less transparent to infrared radiation than it is to short wave radiation however. Trace quantities of water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and a few other gases absorb some of the out-going infrared radiation, re-radiating it back to the earth's surface. In this way they act like the glass covering on a greenhouse. By preventing a portion of the infrared radiation from escaping to space, these "greenhouse gases" keep global temperatures much warmer than would be the case in their absence.

It is worth noting that the greenhouse effect is a naturally occurring phenomenon; it has not been created by human activity. However, there is concern that human-induced changes in the atmospheric concentrations of the greenhouse gases may significantly enhance the naturally occurring greenhouse effect. Although some evidence of the expected increase in global mean temperature has already been noted, an unequivocal demonstration of the enhanced greenhouse effect is not expected for at least another decade (Intergovernmental Panel on Climate Change, 1992). Studies have demonstrated conclusively, however, that the atmospheric concentrations of CO_2, CH_4 and N_2O have significantly increased from their pre-industrial values as a result of anthropogenic emissions (ibid.).[3] Humankind has also introduced a new and extremely powerful set of greenhouse gases into the atmosphere. Known collectively as the chlorofluorocarbons (CFCs), each of these has thousands of times the ability of CO_2 to absorb infrared radiation.

ESTIMATED 1985 GREENHOUSE GAS EMISSIONS BY ECONOMIC SECTOR

Table 1 lists the greenhouse gases that are included in this study. Emissions of these gases result from the activities of businesses, households[4] and governments. All three sectors purchase and consume commodities that either contain greenhouse gases that are released upon use

3. Although water vapour is the most important greenhouse gas in terms of overall warming power, its atmospheric concentration is not affected significantly by human activities.
4. Households in this context include non-profit organisations.

(paints and solvents, for example) or that are converted to greenhouse gases as a result of use (fossil fuels are the most important example of the latter type of commodity). Using the emissions data discussed at the end of this chapter in combination with data from the 1985 input-output tables, it has been possible to estimate the 1985 greenhouse gas emissions from 49 industries and 4 categories of household and government expenditure. These estimates are shown in Table 2.

Table 1: Greenhouse Gases Included in this Study

Name	Formula / Acronym
Carbon dioxide	CO_2
Methane	CH_4
Nitrous oxide	N_2O
Volatile organic carbon compounds	VOCs
Nitric oxide and nitrogen dioxide	NO_x
Carbon monoxide	CO

The data presented in Table 2 show that the electric power and other utilities industry (34) was the largest industrial emitter of CO_2 in 1985. This industry also rates as the largest industrial emitter when ranked in terms of CO_2 equivalent emissions.[1] The transportation industry (30), primary metals industry (20), agriculture industry (1), and chemical products industry (27) make up the remainder of the top five industrial emitters in terms of CO_2 equivalents.

The concentration of industrial greenhouse gas emissions is highlighted by the fact that these five industries alone accounted for almost 58% of total CO_2 equivalent emissions from industries in 1985. The top ten emitters accounted for 76% of total industrial CO_2 equivalent emissions.

A direct cause and effect relationship exists between fossil fuel consumption and greenhouse gas emissions. It is not surprising, then, that four of the top five CO_2 equivalent emitting industries also rank among the five largest industrial consumers of fossil fuels. The agriculture industry stands out as something of an anomaly in this regard. It ranks fourth in terms of CO_2 equivalent emissions, but eighth in terms of fossil fuel consumption. The reason for the relatively high ranking of the agriculture industry in

1. CO_2 equivalent emissions are calculated using the concept of global warming potential (Intergovernmental Panel on Climate Change, 1992). Global warming potential (GWP) is the potential contribution to global warming over a specified time period (usually 20 or 100 years) of a given greenhouse gas relative to that of CO_2, which is assigned a GWP of 1. When 100 years is the considered time period, methane is calculated to have a GWP of 11, and nitrous oxide to have a GWP of 270. This means, for example, that the emission of one tonne of CH_4, considered over a period of 100 years from the date of emission, is equivalent to the emission of 11 tonnes of CO_2 in terms of its potential contribution to global warming.

   No GWP values exist for VOCs, NO_x and CO. Thus, it is not possible to include these gases in CO_2 equivalent emission estimates. The reader is cautioned to keep this exclusion in mind when interpreting the CO_2 equivalent emission data presented here.

Table 2: Greenhouse Gas Emissions by Sector, 1985

Sector	CO_2	CO_2 equiv.[1]	CH_4	N_2O	VOC	NO_x	CO	CO_2	CO_2 equiv.[1]
	kilotonnes							rank	
Business sector									
1 Agriculture	9 525	24 663	973	16	64	127	610	8	4
2 Fishing and trapping	1 134	1 187	--	--	10	14	96	29	29
3 Logging and forestry	2 076	2 151	--	--	10	30	88	21	21
4 Mining	6 563	8 220	140	--	7	48	81	14	12
5 Crude oil and natural gas	7 845	16 459	779	--	33	184	143	11	6
6 Quarries and sand pits	474	488	--	--	1	7	10	35	35
7 Services related to mineral extraction	2 303	2 381	--	--	14	29	136	20	20
8 Food processing	4 773	4 816	--	--	10	9	33	15	16
9 Beverages	1 054	1 064	--	--	2	3	8	30	30
10 Tobacco products	63	63	--	--	--	--	--	46	46
11 Rubber products	511	514	--	--	5	2	1	34	34
12 Plastic products	350	353	--	--	1	--	2	40	40
13 Leather products	126	127	--	--	--	--	--	45	45
14 Textiles	1 263	1 269	--	--	2	2	6	27	28
15 Clothing	231	233	--	--	--	--	2	43	43
16 Wood products	1 796	1 815	--	--	48	10	860	23	23
17 Furniture	315	318	--	--	4	--	2	42	42
18 Paper products	9 985	10 046	--	--	19	38	96	7	9
19 Printing and publishing	423	427	--	--	1	1	4	38	38
20 Primary metals	24 492	25 060	--	2	15	35	449	3	3
21 Fabricated metals	2 002	2 017	--	--	12	2	8	22	22
22 Machinery	760	766	--	--	3	1	4	33	33
23 Transport equipment	2 772	2 791	--	--	28	4	11	19	19

Table 2: Greenhouse Gas Emissions by Sector, 1985

Sector	CO_2	CO_2 equiv.[1]	CH_4	N_2O	VOC	NO_x	CO	CO_2	CO_2 equiv.[1]
	kilotonnes							rank	
24 Electrical products	989	995	--	--	4	1	7	31	31
25 Non-metallic minerals	12 678	12 721	--	--	5	27	62	4	7
26 Refined petroleum	8 201	8 302	--	--	51	39	240	10	11
27 Chemical products	12 612	16 903	--	16	233	29	31	5	5
28 Other manufacturing	450	454	--	--	3	1	3	36	36
29 Construction	7 511	7 848	1	1	132	93	841	12	13
30 Transport industry	33 713	34 874	14	4	98	259	614	2	2
31 Pipeline transport	4 519	4 891	32	--	--	--	--	16	15
32 Storage	418	423	--	--	--	--	3	39	39
33 Communication	1 417	1 453	--	--	8	7	63	25	26
34 Electric power & other utilities	84 540	85 300	16	2	15	272	142	1	1
35 Wholesale trade	7 239	7 537	1	1	60	48	418	13	14
36 Retail trade	8 760	8 983	1	1	44	34	305	9	10
37 Finance and real estate	11 444	11 540	--	--	9	10	66	6	8
38 Insurance	161	165	--	--	1	1	5	44	44
39 Government royalties on resources	-	-	-	-	-	-	-	..	..
40 Owner occupied dwellings	-	-	-	-	-	-	-	...	..
41 Business services	1 412	1 456	--	--	9	7	66	26	25
42 Education services	330	332	--	--	--	--	1	41	41
43 Health services	1 258	1 290	--	--	6	4	41	28	27
44 Accommodation and food	4 331	4 361	--	--	1	2	10	17	18
45 Amusement and recreation	440	445	--	--	1	1	4	37	37
46 Personal services	946	961	--	--	21	2	14	32	32
47 Other services	1 673	1 736	--	--	13	9	90	24	24
48 Operating supplies	-	-	-	-	47	-	-	47	47
49 Travel, advertising & promotion	4 300	4 536	1	1	55	39	386	18	17
50 Transportation Margins	-	-	-	-	-	-	-	.	..
Sub-total, business sector	**290 181**	**323 596**	**1 962**	**48**	**1 106**	**1 432**	**6 060**		
Household sector									
Motor fuels & lubricants	40 694	44 709	11	14	374	251	2 514	...	..
Home heating fuels	48 719	48 986	2	1	111	41	641	.	...
All other goods	3 007	3061	0	0	101	7	55	..	.
Government - current expenditures	17 859	18 225	2	1	59	52	289	..	.
Sub-total, household and government sectors	**110 278**	**114 980**	**15**	**17**	**645**	**351**	**3 499**	...	...
Total, whole economy	**400 459**	**438 576**	**1 977**	**65**	**1 750**	**1 783**	**9 559**	...	...

Notes:
Readers familiar with input-output accounting will note that the format of this table does not correspond exactly to that of the national input-output tables. Specifically, the following categories of final demand have been excluded: fixed capital formation, inventory change, imports and exports. These have been excluded because they do not result in direct greenhouse gas emissions and because their exclusion simplifies the presentation.
Industries 48, 49 and 50 are fictive industries used for estimating the use of groups of commodities whose precise content is unknown.
[1] CO_2 equivalent emissions include CO_2 emissions plus N_2O and CH_4 emissions expressed as equivalent CO_2 emissions.

terms of CO_2 equivalents is found in its very large emissions of CH_4 and N_2O. Farm animals, cattle in particular, release a great deal of CH_4 during their digestion processes. This accounts for almost all of the CH_4 emissions from the agriculture industry. Nitrification processes in soils to which nitrogenous fertilizers have been applied account for the very large emissions of N_2O. The agriculture industry is estimated to have accounted for 50% of total industrial CH_4 emissions and 33% of total industrial N_2O emissions in 1985.[1]

Table 2 shows an estimated 114 980 kt of CO_2 equivalent emissions from households and governments in 1985, which represents more than 26% of the economy-wide emissions. The majority (93%) of household and govern-

1. Had it been possible to include landfill CH_4 emissions in this study, other industries would have shown higher CH_4 emissions in Table 2 to the extent that they contribute to bio-degradable material in landfill sites. Since landfill CH_4 emissions represent 38% of total CH_4 emissions as estimated by Environment Canada (Jaques, 1992, p. xviii), this exclusion puts the agriculture industry in an unfairly poor light in comparison to other industries.

ment CO_2 equivalent emissions come from the consumption of motor and heating fuels.

The conventional wisdom that industry, especially heavy manufacturing, is the major polluter in the economy is borne out by the results presented in Table 2, at least in terms of greenhouse gas emissions. It should not be left unsaid, however, that households account for more CO_2 equivalent emissions than any single industry.

GREENHOUSE GAS INTENSITY OF PRODUCTION

It is possible, using an input-output model, to estimate the greenhouse gas emissions associated with the delivery of $1 000 of a given commodity (that is, a good or a service) to final consumption.[1] The nature of input-output models is such that both the direct and indirect emissions associated with commodity production can be included in these estimates. Direct emissions are defined as the emissions from the commodity producing industry. Emissions from those industries that supply the producing industry with the inputs used in the commodity's production are defined as indirect emissions. Table 3 shows the direct and indirect greenhouse gas emissions associated with the delivery to final consumers of $1 000 worth of each of 92 unique commodities.

1. Final consumption includes household consumption expenditure, investment in fixed capital, inventory change, government current expenditure and net exports.

The first value in Table 3 indicates that in 1985 each $1 000 worth of grain purchased by final consumers resulted in the emission of an estimated 0.8963 t of CO_2 from Canadian industries. The other values shown in Table 3 can be similarly interpreted.

It is interesting to compare the greenhouse gas intensity of various commodities but, before doing so, a note of caution is in order. In many cases, more than one commodity is produced by a given industry. For example, both grains and live animals are produced by the agriculture industry. In these cases, the greenhouse gas intensity of the co-produced commodities will be identical, and will reflect the average intensity of one unit of "production" from the industry regardless of what commodities comprise this production. The reader is warned, then, not to take the rankings of co-produced commodities as absolute, but in-

Table 3: Greenhouse Gas Intensity of Commodities, 1985

Commodity	CO_2	CO_2 equiv.[1]	CH_4	N_2O	VOC	NO_x	CO	CO_2	CO_2 equiv.[1]
	tonnes per thousand dollars							rank	
1 Grains	0.8963	1.7768	0.0555	0.0010	0.0054	0.0087	0.0386	28	12
2 Live animals	0.8963	1.7768	0.0555	0.0010	0.0054	0.0087	0.0386	27	11
3 Other agricultural products	0.8968	1.7707	0.0549	0.0010	0.0053	0.0087	0.0384	26	13
4 Forestry products	0.7561	0.8194	0.0033	0.0001	0.0037	0.0080	0.0255	34	43
5 Fish landings	1.1486	1.2268	0.0022	0.0002	0.0091	0.0134	0.0859	19	25
6 Hunting & trapping products	1.1486	1.2268	0.0022	0.0002	0.0091	0.0134	0.0859	20	26
7 Iron ores & concentrates	1.0858	1.2866	0.0158	0.0001	0.0019	0.0068	0.0136	23	24
8 Other metal ores & concentrates	1.2093	1.3826	0.0133	0.0001	0.0020	0.0063	0.0165	17	20
9 Coal	1.0859	1.2867	0.0158	0.0001	0.0019	0.0068	0.0136	22	23
10 Crude mineral oils	0.4835	0.7761	0.0266	0.0000	0.0017	0.0071	0.0082	66	46
11 Natural gas	0.4871	0.7775	0.0264	0.0000	0.0018	0.0071	0.0083	65	45
12 Non-metallic minerals	0.8894	1.0660	0.0136	0.0001	0.0026	0.0079	0.0134	29	28
13 Services incidental to mining	0.8305	0.8795	0.0020	0.0001	0.0042	0.0075	0.0329	30	41
14 Meat products	0.7083	1.0286	0.0193	0.0004	0.0033	0.0046	0.0198	40	30
15 Dairy products	0.7091	1.0272	0.0191	0.0004	0.0032	0.0046	0.0197	39	34
16 Fish products	0.7115	1.0285	0.0190	0.0004	0.0032	0.0047	0.0201	36	31
17 Fruit & vegetable preparations	0.7051	1.0188	0.0187	0.0004	0.0032	0.0046	0.0196	42	36
18 Feeds	0.7050	1.0165	0.0185	0.0004	0.0032	0.0046	0.0196	43	37
19 Flour, wheat, meal & other cereals	0.7093	1.0274	0.0191	0.0004	0.0032	0.0046	0.0197	38	32
20 Breakfast cereal & bakery products	0.6905	0.9618	0.0173	0.0003	0.0032	0.0044	0.0189	45	40
21 Sugar	0.7093	1.0274	0.0191	0.0004	0.0032	0.0046	0.0197	37	33
22 Miscellaneous food products	0.7061	1.0209	0.0188	0.0004	0.0033	0.0046	0.0197	41	35
23 Soft drinks	0.6271	0.6816	0.0025	0.0001	0.0019	0.0025	0.0092	49	52
24 Alcoholic beverages	0.6270	0.6815	0.0025	0.0001	0.0019	0.0025	0.0092	50	53
25 Tobacco, processed unmanufactured	0.4016	0.5012	0.0066	0.0001	0.0017	0.0023	0.0100	78	69
26 Cigarettes & tobacco, manufactured	0.4016	0.5012	0.0066	0.0001	0.0017	0.0023	0.0100	79	70
27 Tires & tubes	0.5814	0.6486	0.0012	0.0002	0.0045	0.0022	0.0053	55	54

Table 3: Greenhouse Gas Intensity of Commodities, 1985

	Commodity	CO_2	CO_2 equiv.[1]	CH_4	N_2O	VOC	NO_x	CO	CO_2	CO_2 equiv.[1]
		tonnes per thousand dollars							rank	
28	Other rubber products	0.5595	0.6300	0.0015	0.0002	0.0041	0.0021	0.0054	57	58
29	Plastic fabricated products	0.6252	0.6957	0.0015	0.0002	0.0045	0.0022	0.0067	51	51
30	Leather & leather products	0.3737	0.4205	0.0018	0.0001	0.0017	0.0015	0.0050	81	77
31	Yarns & man made fibres	0.6046	0.6437	0.0011	0.0001	0.0025	0.0018	0.0052	52	55
32	Fabrics	0.5893	0.6273	0.0010	0.0001	0.0023	0.0017	0.0051	54	59
33	Other textile products	0.5931	0.6311	0.0010	0.0001	0.0024	0.0018	0.0052	53	56
34	Hosiery & knitted wear	0.2678	0.2788	0.0010	0.0000	0.0010	0.0010	0.0038	86	86
35	Clothing & accessories	0.2773	0.2883	0.0010	0.0000	0.0010	0.0010	0.0039	85	85
36	Lumber & timber	0.6619	0.7076	0.0017	0.0001	0.0067	0.0046	0.0937	46	48
37	Veneer & plywood	0.6588	0.7045	0.0017	0.0001	0.0067	0.0046	0.0951	47	49
38	Other wood fabricated materials	0.6567	0.7024	0.0017	0.0001	0.0065	0.0045	0.0888	48	50
39	Furniture & fixtures	0.4607	0.4976	0.0009	0.0001	0.0028	0.0017	0.0140	69	71
40	Pulp	1.2551	1.3041	0.0020	0.0001	0.0034	0.0056	0.0192	13	21
41	Newsprint & other paper stock	1.2516	1.3006	0.0020	0.0001	0.0034	0.0056	0.0193	15	22
42	Paper products	1.1080	1.1559	0.0019	0.0001	0.0034	0.0048	0.0167	21	27
43	Printing & publishing	0.4115	0.4203	0.0008	0.0000	0.0014	0.0018	0.0068	75	78
44	Advertising & print media	0.4024	0.4112	0.0008	0.0000	0.0014	0.0017	0.0067	77	80
45	Iron & steel products	1.7957	1.8849	0.0032	0.0002	0.0020	0.0042	0.0296	9	9
46	Aluminum products	1.8807	1.9710	0.0033	0.0002	0.0020	0.0044	0.0311	7	7
47	Copper & copper alloy products	1.8711	1.9614	0.0033	0.0002	0.0020	0.0044	0.0309	8	8
48	Nickel products	1.8991	1.9905	0.0034	0.0002	0.0020	0.0045	0.0314	5	6
49	Other non ferrous metal products	1.7604	1.8496	0.0032	0.0002	0.0023	0.0042	0.0287	10	10
50	Boilers, tanks & plates	0.6995	0.7452	0.0017	0.0001	0.0020	0.0020	0.0096	44	47
51	Fabricated structural metal products	0.9377	0.9856	0.0019	0.0001	0.0021	0.0026	0.0139	25	38
52	Other metal fabricated products	0.7413	0.7870	0.0017	0.0001	0.0021	0.0021	0.0105	35	44
53	Agricultural machinery	0.4295	0.4383	0.0008	0.0000	0.0012	0.0013	0.0064	72	74
54	Other industrial machinery	0.5271	0.5684	0.0013	0.0001	0.0016	0.0017	0.0080	63	64
55	Motor vehicles	0.3313	0.3379	0.0006	0.0000	0.0015	0.0010	0.0046	84	84
56	Motor vehicle parts	0.3430	0.3496	0.0006	0.0000	0.0015	0.0011	0.0047	82	82
57	Other transport equipment	0.4242	0.4330	0.0008	0.0000	0.0017	0.0018	0.0064	73	75
58	Household appliances & receivers	0.4106	0.4194	0.0008	0.0000	0.0014	0.0013	0.0063	76	79
59	Other electrical products	0.3807	0.3884	0.0007	0.0000	0.0013	0.0012	0.0059	80	81
60	Cement & concrete products	2.7703	2.8237	0.0024	0.0001	0.0023	0.0072	0.0168	3	3
61	Other non-metallic mineral products	2.5183	2.5706	0.0023	0.0001	0.0024	0.0066	0.0158	4	4
62	Gasoline & fuel oil	0.7634	0.9730	0.0166	0.0001	0.0037	0.0063	0.0163	33	39
63	Other petroleum & coal products	0.8114	1.0458	0.0164	0.0002	0.0052	0.0061	0.0136	32	29
64	Industrial chemicals	1.2530	1.5681	0.0041	0.0010	0.0151	0.0044	0.0097	14	14
65	Fertilizers	1.0299	1.5340	0.0311	0.0006	0.0057	0.0073	0.0237	24	16
66	Pharmaceuticals	1.2420	1.5582	0.0042	0.0010	0.0158	0.0043	0.0091	16	15
67	Other chemical products	1.2023	1.5218	0.0045	0.0010	0.0148	0.0043	0.0095	18	17
68	Scientific equipment	0.4344	0.4735	0.0011	0.0001	0.0021	0.0016	0.0069	70	73
69	Other manufactured products	0.5485	0.5953	0.0018	0.0001	0.0023	0.0019	0.0083	59	60
70	Residential construction	0.5311	0.5724	0.0013	0.0001	0.0035	0.0033	0.0231	61	62
71	Non-residential construction	0.5311	0.5724	0.0013	0.0001	0.0035	0.0033	0.0231	60	61
72	Repair construction	0.5311	0.5724	0.0013	0.0001	0.0035	0.0033	0.0231	62	63
73	Pipeline transportation	1.8972	2.0501	0.0139	0.0000	0.0004	0.0018	0.0024	6	5
74	Transportation & storage	1.3950	1.4776	0.0026	0.0002	0.0044	0.0101	0.0258	11	18
75	Radio & television broadcasting	0.2085	0.2129	0.0004	0.0000	0.0010	0.0010	0.0064	91	91
76	Telephone & telegraph	0.2085	0.2129	0.0004	0.0000	0.0010	0.0010	0.0064	90	90
77	Postal services	0.2085	0.2129	0.0004	0.0000	0.0010	0.0010	0.0064	89	89
78	Electric power	4.7870	4.8338	0.0018	0.0001	0.0012	0.0157	0.0098	1	1
79	Other utilities	4.7827	4.8295	0.0018	0.0001	0.0012	0.0156	0.0098	2	2
80	Wholesale margins	0.4793	0.5250	0.0017	0.0001	0.0030	0.0027	0.0167	68	66
81	Retail margins	0.4904	0.5025	0.0011	0.0000	0.0018	0.0021	0.0117	64	68
82	Imputed rent, owner occupied dwellings	0.0337	0.0348	0.0001	0.0000	0.0002	0.0002	0.0013	92	92

Table 3: Greenhouse Gas Intensity of Commodities, 1985

	Commodity	CO_2	CO_2 equiv.[1]	CH_4	N_2O	VOC	NO_x	CO	CO_2	CO_2 equiv.[1]
		tonnes per thousand dollars							rank	
83	Other finance, insurance & real estate	0.4206	0.4305	0.0009	0.0000	0.0009	0.0012	0.0049	74	76
84	Business services	0.2149	0.2204	0.0005	0.0000	0.0012	0.0011	0.0068	88	88
85	Education services	0.5570	0.5658	0.0008	0.0000	0.0010	0.0016	0.0050	58	65
86	Health services	0.2173	0.2217	0.0004	0.0000	0.0010	0.0009	0.0056	87	87
87	Amusement & recreation services	0.3333	0.3399	0.0006	0.0000	0.0010	0.0012	0.0055	83	83
88	Accommodation & food services	0.5609	0.6308	0.0039	0.0001	0.0011	0.0019	0.0068	56	57
89	Other personal & miscellaneous services	0.4794	0.5163	0.0009	0.0001	0.0028	0.0021	0.0119	67	67
90	Transportation margins	1.3543	1.4099	0.0026	0.0001	0.0042	0.0098	0.0250	12	19
91	Operating, office, lab. & food supplies	0.4329	0.4863	0.0024	0.0001	0.0046	0.0020	0.0084	71	72
92	Travel, advertising & promotion	0.8121	0.8622	0.0021	0.0001	0.0054	0.0056	0.0350	31	42

Note:
[1] CO_2 equivalent emissions include CO_2 emissions plus N_2O and CH_4 emissions expressed as equivalent CO_2 emissions.

stead as general indicators of their greenhouse gas intensity relative to other commodities.

When either CO_2 or CO_2 equivalent emission intensity is considered, electric power (78) was the most polluting commodity produced in the Canadian economy in 1985. “Other utilities” (79) (mainly natural gas and water supply) ranked second. Note that commodity 79 is co-produced with electricity by the electric power and other utilities industry (industry 34 in Table 2). Cement (60) and other nonmetallic mineral products (61) were ranked next. Pipeline transportation (73) and the primary metals - iron and steel (45), aluminum (46), copper (47), nickel (48) and other non-ferrous metals (49) - round out the list of the ten most highly CO_2 intensive commodities produced in 1985.

The agricultural and food commodities (1-3 and 14-22) show significant increases in intensity when ranked in order of CO_2 equivalents. This change is expected given the large emissions of CH_4 and N_2O from the agriculture industry shown in Table 2 above.

INDUSTRIAL EMISSIONS BY FINAL DEMAND CATEGORY

Production activity takes place to meet the demand for commodities from final consumers. It is reasonable, then, to ask what portion of total industrial greenhouse gas emissions are attributable to the production required to meet the demand from different final consumption categories. Table 4 shows such a breakdown of industrial greenhouse gas emissions.[1] As one might expect, production to meet the demand for commodities from households is responsible for the greatest portion of industrial greenhouse gas emissions.

Some explanation is required for the row labelled “imports” in Table 4. The emissions reported in this row are not the actual emissions that occurred in other countries during the manufacturing of Canada’s imported commodities. Rather, they represent the emissions that would have obtained had we produced domestically, instead of importing, this group of commodities. The assumption implicit in these estimates is that foreign industries emit the same quantities of greenhouse gases in producing one unit of a particular commodity as do Canadian industries.

The results reported in Table 4 indicate that Canada exported a more greenhouse gas intensive set of goods and services than it imported in 1985. Put another way, Canada was a net exporter of greenhouse gas emissions as a result of its international trade.

CO_2 EMISSIONS PER UNIT OF ENERGY CONSUMPTION, 1970-1990

It was noted above that greenhouse gas emissions are causally related to fossil fuel consumption. In particular, anthropogenic CO_2 emissions result mainly from the combustion of fossil fuels.

The magnitude of fuel combustion-related CO_2 emissions is a function of two variables. Most obviously, the quantity of fossil fuels burned has a direct impact on the magnitude of CO_2 emissions. Less obvious is the effect of the variability of CO_2 emissions per unit of energy across fossil fuel types. Since each fuel type results in different CO_2 emissions per unit of energy, the composition of overall energy consumption will affect aggregate CO_2 emissions. A shift in consumption from coal to natural gas, for example, would result in lower CO_2 emissions, other things equal, since natural gas combustion results in only 55% as

1. It must be emphasized that the figures shown in Table 4 are the emissions associated with the production activity required to meet the demand for commodities from final consumption categories. They do not represent the emissions associated with the consumption of these commodities once they have been purchased. The latter were shown in Table 2.

Table 4: Industrial Greenhouse Gas Emissions by Demand Category, 1985

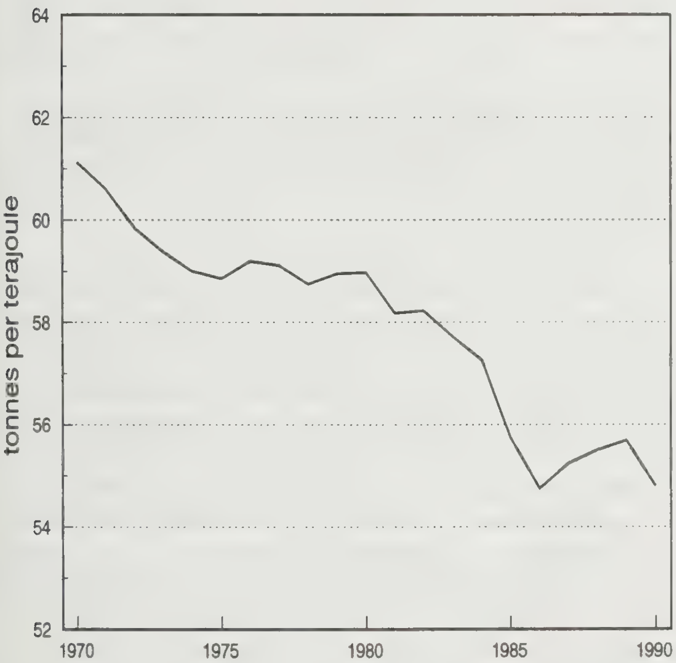
Final Demand Category	CO_2	CO_2 equiv.[1]	CH_4	N_2O	VOC	NO_x	CO
	kilotonnes						
Household expenditure	127 299	142 198	839	21	402	586	2 060
Investment in fixed capital	39 423	41 829	96	5	238	226	1 502
Exports	98 433	113 259	906	18	358	502	2044
Imports	69 088	78 550	492	15	298	288	1 105
Government current expenditure	21 685	23 320	75	3	94	103	383

Note:
1. CO_2 equivalent emissions include CO_2 emissions plus N_2O and CH_4 emissions expressed as equivalent CO_2 emissions.

much CO_2 per unit of energy as does the combustion of coal (Jaques, 1992, p. xx).

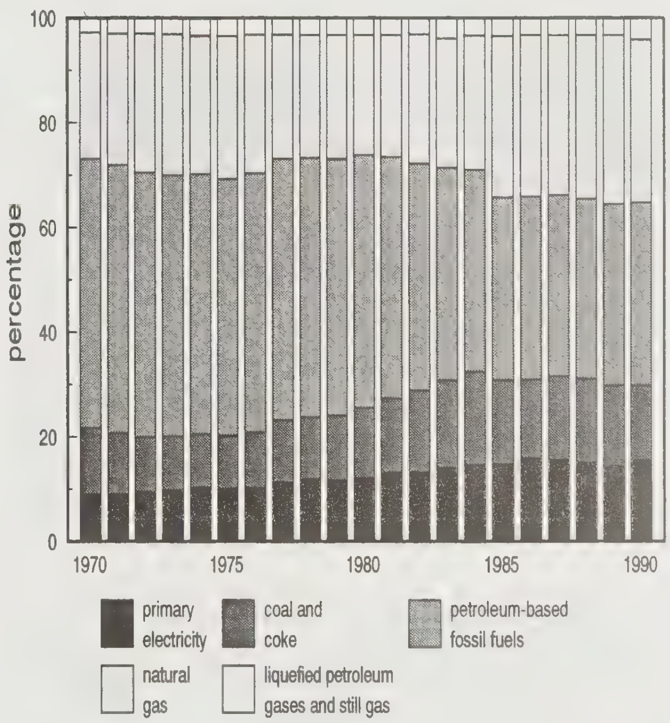
Figure 1 shows the effect on total fossil fuel combustion-related CO_2 emissions of the changing composition of Canadian energy consumption during the period 1970-1990. It is clear from this figure that the trend in Canada since 1970 has been toward a less CO_2 intensive energy mix. CO_2 emissions per unit of total energy consumption declined at an annual rate of 0.29 t/TJ over this period.

Figure 1: Direct CO_2 Emissions per Unit of Energy Consumption, 1970-1990



The reasons for the decline in the CO_2 intensity of energy consumption can be seen in Figure 2, which shows the composition of total energy consumption during the period 1970-1990. During the past two decades, the share in Canadian energy consumption of both natural gas and primary electricity (hydro and nuclear) has increased, entirely at the expense of petroleum-based fossil fuels.[1] Since natural gas is the least CO_2 intensive fossil fuel (ibid.), and primary electricity does not result in any direct CO_2 emissions, this change in energy mix results in the decreasing trend shown in Figure 1. The percentage of consumption met by coal also increased during this period, but not enough to offset the reduction in CO_2 intensity resulting from the increased share of natural gas and primary electricity.

Figure 2: Composition of Total Energy Consumption, 1970-1990



1. Petroleum-based fossil fuels include diesel fuel, light and heavy fuel oils, kerosene, motor and aviation fuels.

CONCLUSION

Several useful pieces of information have emerged from the results presented above. Perhaps most important is the highly concentrated nature of industrial greenhouse gas emissions. When considered in terms of CO_2 equivalent emissions, the five largest industrial sources accounted for almost 58% of 1985 industrial emissions. Particularly noteworthy is the fact that the electric power and other utilities industry alone was responsible for 26% of all industrial emissions. The very large emissions from this industry meant that electricity was the most greenhouse gas intensive commodity in the Canadian economy in 1985. Each $1 000 worth of electricity delivered to final consumers resulted in the emission of nearly 5 tonnes of CO_2 equivalents.

The importance of transportation activity in total greenhouse gas emissions is also clear from the above analysis. The transportation industry (which includes for-hire land, air and marine transportation services) is the second largest source of CO_2 equivalent gas emissions among all industries. This is so even though the emissions from transportation activity undertaken by firms, households or governments on own-account are not included in the estimated emissions from the transportation industry. All told, transportation is a significant source of greenhouse gas emissions.

Households also appear as very important sources of greenhouse gas emissions. The consumption of commodities by households contributed almost 22% of economy-wide 1985 CO_2 equivalent emissions. On top of this are the 142 Mt of CO_2 equivalent emissions, or 44% of total industrial emissions (see Table 4), that are associated with the production of commodities ultimately purchased by households. This is not meant to imply that households are solely responsible for the greenhouse gases emitted during the production of the commodities they purchase; the responsibility for these emissions must be shared between the consumers who demand the commodities and the industries that meet this demand. Nonetheless, it serves to highlight the importance of household consumption in overall greenhouse gas emissions.

To conclude, it can be said that the input-output accounting and modelling frameworks have proven to be useful tools for the analysis of greenhouse gas emissions. The majority of anthropogenic greenhouse gas emissions have been included in the input-output model used here and some interesting results have followed. However, where the nature of emissions is such that there exists no linear and constant relationship to annual economic activity, specifically in the cases of CFCs and landfill methane emissions, the input-output framework alone is inappropriate. Future work will require the development of extensions to the framework that will allow the incorporation of emissions that are sporadic, stock driven or otherwise related in an non-linear way to human activity.

DATA SOURCES AND EMISSION ESTIMATION METHOD

The gases considered in this study include carbon dioxide, methane, nitrous oxide, volatile organic compounds (VOC), nitric oxide and nitrogen dioxide (collectively, NO_x) and carbon monoxide (CO).

Chlorofluorocarbons are notable for their absence in this list. The reason for this absence is explained briefly a few paragraphs below. Also missing from the list is tropospheric ozone (O_3)[1], another powerful greenhouse gas. Tropospheric ozone has been excluded because it is not emitted to an appreciable extent as a by-product of economic activity. Instead, it is formed in the troposphere through chemical reactions involving the precursor gases VOC, NO_x and CO, all of which are emitted in large quantities as by-products of economic activities.

The method and coefficients used in the estimation of the 1985 emissions of carbon dioxide, methane and nitrous oxide have been adopted from an Environment Canada report titled *Canada's Greenhouse Gas Emissions Estimates for 1990* (Jaques, 1992). The CO_2, CH_4 and N_2O emission estimates reported here are, with some important differences, directly comparable with those published for 1990 by Environment Canada.

The first, and most obvious, difference between the estimates reported here and those reported by Environment Canada is that the former are for the year 1985, while the latter are for the year 1990. It was not possible to use 1990 as the base year for this study as no input-output tables for that year are yet available. 1985 was chosen instead, because of the availability of a good inventory of VOC, NOx and CO emissions.

More significant than the choice of a different base year is the exclusion of CFC emissions in the present study. This exclusion is due in part to a lack of data to establish the link between CFC emissions and economic activity at the detailed level represented in the input-output tables. It is also a function of the somewhat inflexible nature of the input-output structure which only allows the modelling of greenhouse gas emissions with constant and linear relationships to annual economic activity. Many types of CFC emissions do not meet this criterion. In any given year CFC emissions are, to a large extent, determined by the stock of the chemicals that has accumulated in prior years and, therefore, bear little relationship to economic activity in that year.[2]

A third departure is the exclusion here of several emission sources included in the Environment Canada report. These have been excluded mainly because of the afore-

1. The troposphere is the lowest level of the earth's atmosphere.

2. Environment Canada estimates that 1990 CFC emissions amounted to 11 kt (Jaques, 1992, p. xviii).

mentioned lack of data and/or inflexibility of the input-output framework. With respect to CO_2, emissions from non-energy uses of petroleum products other than ammonia production (1990 estimate: approximately 10 000 kt) have been excluded, as well as all biomass related CO_2 emissions.[1] The following sources of CH_4 emissions have also been excluded: waste incineration (< 2 kt), landfill sites (1 405 kt) and slash burning (38 kt). As already noted, landfill sites account for 38% of the total 1990 CH_4 emissions estimated by Environment Canada (Jaques, 1992; p. xviii). Thus, the estimated total 1985 CH_4 emissions reported here are significantly lower than Environment Canada's 1990 estimate. Finally, the emissions of N_2O from nitric acid production, anaesthetics, propellants and high-voltage transmission lines have all been excluded here. These sources account for less than one percent of total 1990 N_2O emissions estimated by Environment Canada.

The last departure from Environment Canada's 1990 greenhouse gas inventory is the inclusion of VOC, NO_x and CO. Only CO_2, CH_4, N_2O and CFC emissions are estimated in the former. The inclusion VOC, NO_x and CO yields more complete information and is not without precedent. A major international body engaged in research on global warming, the Intergovernmental Panel on Climate Change, includes these gases in its list of greenhouse gases (Intergovernmental Panel on Climate Change, 1992), as does the International Energy Agency of the Organisation for Economic Cooperation and Development (International Energy Agency, 1991). For the sake of completeness and because of the international precedents, it was decided that VOC, NO_x and CO should be included in this study.

. The estimated total VOC, NO_x and CO emissions reported in this study match those reported in the *Canadian Emissions Inventory of Common Air Contaminants (1985)* (Kosteltz and Deslauriers, 1990 and Deslauriers, Personal communication) with, again, some important differences. The most significant of these is the exclusion of the following emission sources in the present study: forest fires (201 kt VOC, 37 kt NO_x, 1 141 kt CO); slash burning (96 kt VOC, 20 kt NO_x, 1 134 kt CO); structural fires (6 kt VOC, 12 kt CO); and municipal and industrial incineration (6 kt VOC, 2 kt NO_x, 9 kt CO). These sources have been excluded because they are not related in a linear and constant way to identifiable economic activity.

Another difference with the Environment Canada study, of less importance, is the modified procedure for estimating VOC, NO_x and CO emissions from heavy duty road vehicles (trucks and buses) used in this study. In spite of this, the estimated emissions from these vehicles are in good agreement in the two studies. Furthermore, since heavy duty road vehicles contribute a relatively small proportion of the total emissions of these three gases, the differences in these estimates have little effect on the estimated total emissions. The estimated emissions of VOC, NO_x and CO from government activities are higher than those reported in the other study, also because of a different estimation method. Again, the effect of this difference on total emissions is very small.

It should be emphasized that, the exclusion of the major emission sources mentioned above notwithstanding, the estimated total 1985 VOC, NO_x and CO emissions reported here agree closely with those published in the *Canadian Emissions Inventory of Common Air Contaminants (1985)*.

APPENDIX

The input-output accounts published by Statistics Canada contain detailed information on annual production and consumption activities in the Canadian economy. The accounts consist of three tables. A "make" table lists the dollar values of all commodities produced by each Canadian industry. A "use" table details the purchases of these same commodities by industries for use as inputs in the production of other commodities. These purchases are referred to as intermediate commodity use. A "final demand" table lists the dollar values of commodities purchased by households and governments, investment in fixed capital, inventory change and net exports (exports less imports). The structure of the input-output accounts is such that there exists an identity between total commodity production (from the make table) and intermediate plus final consumption (from the use and final demand tables).

Using the three tables of the input-output accounts, and given two assumptions regarding the structure of production activity, it is possible to derive linear models (called input-output models) of the relationship between final commodity use and the levels of production activity required to meet this use.

A useful quality of input-output models is their ability to capture both the direct and indirect impacts of final demand on production activity. The impact of the demand for automobiles on the output of the automobile industry is a good example. As the demand for automobiles changes, the output of the automobile industry will adjust to reflect this change. This is an example of a direct impact of demand on production activity. There are, however, further impacts that will result from a change in the demand for cars. The steel industry, for instance, will also see the demand for its product affected by such a change. The change in demand for steel is an example of an indirect impact of demand on

1. Biomass emission sources include the combustion of wood and spent pulping liquor wastes at pulp and lumber mills; slash burning; forest fires; fuelwood combustion; municipal and industrial waste incineration; and landfill sites. Environment Canada excludes these emissions from the estimated total CO_2 emissions reported in *Canada's Greenhouse Gas Emissions Estimates for 1990* because of uncertainty in estimating the magnitude of the corresponding natural sink for CO_2 (such as growing forests). Because it did not have a reliable estimate of both the biomass sink and source terms, Environment Canada felt it misleading to include only biomass CO_2 sources in its estimated total emissions. The estimated magnitude of biomass CO_2 emissions in 1990 is 109 Mt (Jaques, 1992, p. xviii).

production activity. Such indirect demands can propagate through many industries of as a result of a change in the demand for just one commodity. Input-output models capture all these changes automatically, estimating the effect of a change in the demand for one or more commodities across the entire spectrum of economic activity.

There are some limitations on input-output modelling that should be noted. Most significant are the "snapshot" representation of the economy in the input-output accounts, and the assumption of fixed proportionality between the inputs employed in production processes and the outputs of these processes. To the extent that technological change is present in the economy, the first assumption limits the capacity of input-output models for accurately predicting future economic activity. Thus, the technique is most useful for studying the impact of demand changes in a given year or, at most, a few years into the future. The second assumption limits the accuracy of input-output models for impact analysis in any time period, as the capacity for input substitution that exists in the actual economy is not captured in the constant-proportion input-output framework.

Beyond purely economic analysis, input-output modelling can also be used to study the relationship between economic activity and the use of raw materials and generation of wastes. To do so requires two modifications to the standard conception of the input-output accounts. First, it is necessary to introduce physical quantities into the input-output framework. Second, the framework must be expanded beyond its normal market-activity boundary to include the non-marketed inputs and outputs of economic activity. Once these changes to the accounting framework are made, the incorporation of environmental inputs and outputs into the framework is conceptually no different than the incorporation of any marketed input or output. Just as industries produce commodities for the marketplace, they also produce waste materials that can be released into the environment. Similarly, just as industries purchase commodities for use in their production processes, they also make use of non-marketed inputs from the environment, air and water for example. It is possible to incorporate tables showing the inputs and outputs of these environmental commodities, in physical quantities, into the standard input-output framework. Assuming that these environmental commodities are produced and consumed in fixed proportion to the production and consumption of marketed commodities, a set of input-output accounts so modified can be used to study the relationship between production, consumption and the use of the environment as a source of raw materials and a sink for wastes.

REFERENCES

Deslauriers, M. Personal communication. October, 1991.

Government of Canada. *Canada's Green Plan for a Healthy Environment.* Ottawa, 1990.

Intergovernmental Panel on Climate Change. *1992 IPCC Supplement (Draft).* In press. 1992.

International Energy Agency. *Greenhouse Gas Emissions: The Energy Dimension.* Paris: Organisation for Economic Cooperation and Development/International Energy Agency. 1991.

Jaques, A. P. *Canada's Greenhouse Gas Emissions: Estimates for 1990.* Environment Canada Report EPS 5/AP/4, Ottawa, 1992.

Kosteltz, A. and M. Deslauriers. *Canadian Emissions Inventory of Common Air Contaminants (1985).* Environment Canada Report EPS 5/AP/3, Ottawa, 1990.

Statistics Canada. *The Input-Output Structure of the Canadian Economy, 1985.* Catalogue No. 15-201, Ottawa, 1989.

Victor, Peter A. *Pollution: Economy and Environment.* United Kingdom: George Allen and Unwin Ltd. 1972.

3 Pulp and Paper Industry Compliance Costs

by Craig Gaston

INTRODUCTION

The pulp and paper industry is currently under considerable scrutiny by environmentalists, regulators and the general public. This resource based industry is the main livelihood for over 76,000 Canadians and has a long history as one of Canada's most important economic activities. The industry has made significant progress over the last 20 years in reducing pollution but as the volume of production has increased and our ability to study the composition and the effects of the pollutants has improved, regulations have become more stringent. The increased concern over pollution comes at a time when U.S. customers are demanding a higher recycled fibre content in newsprint and European buyers are beginning to give preference to paper that has not been bleached with chlorine. These pressures translate necessarily into expensive capital expenditures and coincide with a period of weak demand and increasingly strong competition.

BACKGROUND

Canadian mills are often criticized for being old and inefficient. Fifty-eight percent of Canadian newsprint machines commenced operation prior to 1950 compared to 28% in the U.S. and 7% in Scandinavia. Also, 15% of annual production capacity is greater than 400 tonnes a year in Canada compared to 30% in the U.S., 80% in Sweden, 40% in Finland and 20% in Norway (Sinclair, 1990). Industry analysts claim that Canadian companies must modernize, shift to higher value products such as fine papers, and invest in pulp and paper mills outside of Canada (Headlam and Stevenson, 1990, p. 43).

This study examines the estimated cost of compliance to the 1992 federal regulations on traditional pollutants. How do compliance costs vary according to the type of treatment facility in place? What effect does the age of a mill have on estimated expenditures? How do these costs vary according to region, type of product, capacity, profitability, recent investment or foreign control? The aim of this chapter is to shed light on the nature of the pulp and paper pollution problem in Canada and on how the industry will be affected by certain federal regulations which take effect this year.

Economic Importance of Pulp and Paper

The pulp and paper industry comprised 82 firms which operated 147 mills in 1989. Although concentrated in Quebec, Ontario and British Columbia, plants are located in every province with the exception of Prince Edward Island. In terms of value added, the industry ranks first among all manufacturing industries in Canada, followed by the automobile industry. The industry has declined in relative importance since the fifties, when it accounted for 5.3% of GDP, to 1.4% of GDP in 1989. Canada ranks second in the world in terms of wood pulp production, and first in terms of exports of this commodity. Pulp and paper products accounted for 15% of total exports and 0.6% of employment in 1990.

The industry is currently under considerable financial pressure due to a combination of economic and environmental factors. The recent recession has resulted in many temporary mill shutdowns and several permanent closings. Environmentally, U.S. customers' increasing insistence upon recycled paper content and stricter pollution regulations portend large capital expenditures for de-inking mills and pollution abatement equipment.

Environmental Concerns

The pulp and paper industry is the focus of considerable attention due to its environmental impact. In 1987, waste discharges from the pulp and paper industry were the major industry-related environmental concern in British Columbia and New Brunswick according to provincial environmental authorities (Sinclair, 1990, p. 177). In Ontario and Quebec, the industry ranked third amongst polluting industries and only the chemical industry (a major supplier to the pulp and paper industry) and the mining industry were rated as high as the pulp and paper industry Canada-wide (Sinclair, 1990, p. 177). The industry has, however, made substantial environmental improvements over the last 20 years.

Water pollution has received most of the attention accorded to pulp and paper mills. The industry is not "... a significant contributor to global air pollution problems, such as acid rain or warming. Its [air pollution] problems are very localized and most likely nuisance odour-type problems" (Paul Shepson in Jamieson, 1991, p. 12). Pollution discharged to water consists mainly of wood particles too small to be filtered, organic material (mainly lignin) from the wood and waste chemicals used in the pulping and bleaching process. The wood particles, measured as total suspended solids (TSS), upset the aquatic habitat and ruin fish spawning beds. The dissolved organic material decomposes and in the process uses oxygen thereby reducing the ability of the water to support life. This potential is generally measured as biochemical oxygen demand (BOD) expressed in kilograms per tonne of product. Other organic materials such as resins, fatty acids and sulphur com-

pounds are acutely toxic to fish. Mills that use elemental chlorine for bleaching have also been identified as a significant source of dioxins and furans, which are discharged in the wastewater (Environment Canada, 1991, p. 14-19). Environment Canada considers these substances to be highly toxic.

Regulation

The pulp and paper industry is currently faced with new federal regulations governing the release of various pollutants. From 1971 until 1991 only new mills or mills that underwent significant expansion were subject to restrictions under the Fisheries Act. The new constraints, introduced in 1992 and effective in December 1992, apply to all mills (although the criteria are somewhat different for mills discharging their effluent to off-site treatment facilities). The 1992 federal regulations, under the authority of the Fisheries Act, apply to the discharge of BOD, TSS, and effluents acutely lethal to fish. New regulations were also established under the authority of the Canadian Environmental Protection Act (CEPA) requiring the elimination of dioxins and furans from the effluent of pulp and paper mills performing chlorine bleaching. Regulations controlling defoamers and wood chip insecticides were also implemented under CEPA. Some provinces have also passed regulations limiting or banning organochlorines, a whole class of compounds which result from chlorine bleaching and which include dioxins and furans. This study examines the costs related to the abatement of TSS, BOD, and toxicity. Only mills that discharge effluent directly to receiving waters are examined here.

Treatment Facilities for Traditional Pollutants

Primary treatment facilities remove from 80 to 90% of the settleable portion of the suspended solids, usually by means of gravity clarifiers or settling basins. Secondary treatment is designed to remove BOD associated with the dissolved organic materials in the effluent, and normally uses a biological process. In Canada, aerated lagoons are most often used for secondary treatment. The objectives of this process are to reduce the BOD by 70% to 95% and to render the effluent non-toxic to fish. Although these facilities do reduce toxicity they are not effective in eliminating dioxins and furans.

The estimated capital cost to pulp and paper mills to be in compliance with the 1992 regulations is $2.2 billion (1990 dollars) or about $23 million per mill. This cost can vary from over $100 thousand to $100 million depending upon the circumstances of an individual establishment (Department of Fisheries and Oceans, 1991). By way of comparison, the average annual investment from 1978 to 1989 by mills in this study was $16.8 million per mill in 1989 dollars.

Table 1 shows that most pulp and paper mills in this study had primary treatment facilities in 1989 (84%). In 1989, only 30% of the mills in the sample had secondary treatment facilities. On average, mills without secondary treatment produced over 34 kg of BOD per tonne whereas those with these facilities generated effluent containing 8.8 kg per tonne, just over the 1992 federal limit of 5 kg per tonne. On average, the mills considered here generate 11.4 kg of TSS per tonne while the new limit is 7.5 kg per tonne.

Table 1: Treatment Facilities, 1989

Treatment facilities	Mills	TSS	BOD	Capacity
	number	kg per tonne		tonnes per day
None	20	19.3	17.2	379
Primary only	67	8.9	34.2	600
Primary and secondary	37	9.9	8.8	784
All direct discharge mills	**124**	**11.4**	**23.9**	**619**

Source:
Environment Canada, Regulatory Affairs and Program Integration Branch.

The variation in BOD factors by region reflects, to a large degree, the use of secondary treatment. Table 2 shows that only 13% of Quebec mills had secondary treatment facilities in 1989 and the BOD factors were highest in this province. Similarly, Prairie province mills had the lowest average BOD factor and the highest incidence of secondary treatment.

Table 2: Attributes of Mills by Region

Region	Mills	Mills with treatment facilities		Effluent			
		Primary	Secondary	TSS	BOD	TSS	BOD
	number	percentage		kg per tonne per mill		thousand tonnes per day (all mills)	
Atlantic Provinces	19	81	25	13.6	24.5	118	215
Quebec	49	82	13	11.9	28.5	220	888
Ontario	27	96	27	4.6	19.1	75	304
Prairie Provinces	6	100	85	27.9	12.2	88	39
British Columbia	23	81	52	12.6	21.9	234	383
Canada	**124**	**84**	**30**	**11.4**	**23.9**	**735**	**1 829**

Source:
Environment Canada, Regulatory Affairs and Program Integration Branch.

The inverse relationship between BOD factors and the incidence of secondary treatment is not perfect, however, as shown by British Columbia where the BOD factor is almost the same as the Canadian average and more than half the mills have secondary treatment facilities. Process type is another important variable in explaining BOD factors.

COST OF COMPLIANCE TO RECENT FEDERAL REGULATIONS [1]

It is possible to assess the financial impact of the 1992 federal pollution regulations on pulp and paper mills by examining the estimated compliance costs[2] in the light of historical investment and earnings.

Traditionally, measures related to the pulp and paper industry are expressed in terms of a tonne of final product. This measure is widely understood by industry experts but it does not provide an intuitive appreciation for the actual impact of the required expenditures in relation to a mill's earnings. In this study we will examine the compliance costs relative to average annual investment in new plant and equipment and to average annual surplus[3]. In both cases we have calculated averages over time to avoid the cyclical variation which is inherent in data pertaining to this industry. The averages are based upon 12 years of data in the case of investment and 9 years for surplus. The data have been recalculated in 1989 dollars.

We will examine two ratios. The first is the capital cost of compliance per dollar of average investment by each mill. This ratio can be thought of as the number of years of average equivalent investment (AEI). The second ratio is the annualized capital cost plus operating cost per dollar of average surplus[4], hereafter referred to as the annualized cost ratio (ACR). The AEI is interesting in that it shows the impact of the estimated pollution abatement costs in terms of recent historical investment but it is incomplete since the investment in a mill does not reflect a mill's profitability. Table 3 shows that the ratio of average investment to average surplus increases with decreasing surplus suggesting that there is a minimum amount of investment required for a mill to remain competitive and that more profitable mills can distribute a larger proportion of profits as dividends. Of the two ratios, the ACR is perhaps the best measure of the impact of the regulations on a mill.

The AEI seems to be independent of the level of the ACR. However, it is clear that the overall compliance costs per dollar of surplus are inversely proportional to the ACR.

The average capital cost of compliance per mill is estimated at $25.7 million in 1989 dollars compared to $17.0 million of average investment. This is equal to 1.5 years of average equivalent investment (AEI). Average estimated annualized cost per mill is $4.4 million or 7.9% of the average annual surplus of $55.3 million.

Presence of Treatment Facilities

One of the most important factors determining compliance costs is whether a mill has already invested in treatment facilities. Twenty one mills already equipped with primary and secondary facilities must invest, on average, almost $13 million. This amount represents about half of a year's average equivalent investment. In comparison, 13 mills with no treatment facilities must invest almost $27 million or 2.2 years of AEI. This difference results from the combination of higher capital costs and lower average investment for mills without facilities. In terms of the ACR, mills with both types of facility must spend 3% of surplus annually compared to 14% for mills with no facilities. The majority of the mills considered here have primary treatment facilities only.

Capacity

Mill capacity does not seem to be a factor in terms of the years of AEI needed to comply with the regulations except for the smallest mills for which the AEI is 4.69 years. However, there is a clear correlation between mill size and the ACR which ranges from 6% for mills producing more than 1000 tonnes per day to 19.5% for the smallest mills producing less than 200 tonnes per day.

Although there are important economies of scale in this industry, they do not seem to be related to mill capacity. It is the size of the pulp and paper machines that matters: the total output can be produced by one large machine or two or more small ones. From Table 3 it can be seen that mills producing fewer than 300 tonnes per day were substantially less profitable than average yet so were the mills producing between 620 and 800 tonnes per day. The best performing mills had a daily capacity of between 300 and 620 tonnes per day. These mills had an average surplus of $247 per tonne compared to only $232 per tonne for mills producing over 1000 tonnes per day. Mills producing in the range of 620 to 800 tonnes per day are particularly notable, given their size, their relatively high compliance costs and low profitability representing an ACR of 13%.

---

1. Except where explicitly noted, all references to data in this section refer to Table 3.
2. Estimates of capital and operating costs for specific mills were prepared by N. McCubbin Consultants Inc. These data were used by Environment Canada to evaluate the anticipated impact of the Pulp and Paper Effluent Regulations published in the Canada Gazette on December 14, 1991.
3. Surplus is defined here as the value of shipments less the cost of energy, materials and labour. Since the study is conducted at the level of the individual mill, it is not possible in most cases to determine actual profits. Surplus, as defined here, includes head office overhead, certain purchased services, depreciation and profits.
4. The capital cost is expressed as annual payments over 20 years amortized at 8.19% (See McCubbin, 1990, p 63.)

Table 3: Cost of Compliance and Other Measures

									Compliance costs				
											Annualized		
	Mills	Capacity	BOD	Mills with secondary utilities	Average investment	Average surplus	Investment over surplus	Surplus over production	Capital	Operating	Over production	A.E.I.	A.C.R.
	number	tonnes per day	kg per tonne	percent	millions of dollars		dollars per dollar	dollars per tonne	millions of dollars		dollars per tonne	years	percent of surplus
All mills	**86**	**721**	**30.2**	**24.4**	**17.0**	**55.3**	**0.31**	**227**	**25.7**	**2.3**	**18.0**	**1.51**	**7.9**
Treatment													
None	13	504	21.5	...	12.3	35.5	0.35	223	27.2	2.8	31.4	2.22	14.1
Primary only	52	693	40.6	...	15.9	53.5	0.30	226	30.5	2.6	21.7	1.92	9.6
Primary & sec.	21	925	9.8	100.0	22.5	72.1	0.31	230	12.8	1.1	6.8	0.57	2.9
Capacity (tonnes per day)													
Over 1000	17	1 428	24.0	41.2	27.9	111.1	0.25	232	38.3	3.5	13.8	1.37	5.9
800 to 1000	14	885	33.9	28.6	23.4	66.2	0.35	210	28.7	2.3	14.7	1.23	7.0
620 to 800	9	706	43.4	44.4	24.2	46.9	0.52	198	39.0	3.1	26.8	1.61	13.5
300 to 620	34	478	32.3	14.7	11.4	40.0	0.29	247	21.0	1.9	22.1	1.84	9.0
200 to 300	8	273	21.1	12.5	5.7	16.7	0.34	207	7.9	1.4	25.6	1.39	12.3
Under 200	4	136	13.8	0.0	1.3	6.6	0.20	228	6.2	0.8	44.4	4.69	19.5
Year built													
Before 1900	8	365	14.0	0.0	8.6	30.3	0.28	256	13.8	1.1	19.3	1.61	7.5
1900 to 1971	64	769	35.6	18.8	18.8	59.6	0.32	226	29.4	2.7	19.2	1.56	8.5
After 1971	7	619	9.0	100.0	15.2	49.2	0.31	232	5.1	0.4	3.9	0.34	1.7
Product													
Integrated kraft	15	1127	16.2	46.7	21.2	89.5	0.24	241	29.9	2.7	13.7	1.41	5.7
Market kraft	19	746	18.1	47.4	17.6	58.9	0.30	222	20.3	1.6	12.1	1.15	5.5
Mechanical	5	457	11.9	20.0	17.1	27.9	0.61	176	12.5	2.0	18.8	0.73	10.7
Newsprint	29	757	36.2	6.9	17.8	62.2	0.29	237	30.4	2.6	19.6	1.70	8.2
Other paper and board	9	250	10.7	11.1	3.2	16.3	0.19	227	4.5	0.5	11.8	1.43	5.2
Sulphite, semi-chemical and dissolving	9	497	89.2	11.1	19.4	22.9	0.85	159	43.2	4.0	52.5	2.23	33.1
Region													
Atlantic Provinces	11	713	31.8	27.3	17.7	47.3	0.37	190	25.2	2.0	16.4	1.42	8.6
Quebec	36	615	35.1	8.3	15.7	49.3	0.32	242	27.3	2.1	21.4	1.74	8.9
Ontario	17	635	27.2	11.8	11.6	52.5	0.22	250	19.7	2.2	18.2	1.70	7.3
Prairie Provinces	4	633	14.5	75.0	26.5	53.5	0.49	211	10.2	1.2	8.1	0.39	3.8
B.C. coastal	9	1 214	40.8	33.3	29.2	99.8	0.29	229	55.0	5.1	22.1	1.89	9.7
B.C. interior	9	865	10.5	77.8	14.9	50.6	0.29	193	8.6	1.0	6.5	0.58	3.3
Investment													
Capital > average	31	1 052	32.8	32.3	32.0	84.3	0.38	230	38.5	3.5	18.2	1.20	7.9
Capital < average	55	535	28.7	20.0	8.5	39.0	0.22	224	18.5	1.6	17.7	2.17	7.9
Control													
Canadian	54	661	34.3	16.7	15.0	48.0	0.31	221	26.5	2.2	20.4	1.77	9.2
Foreign	32	823	23.2	37.5	20.2	67.7	0.30	234	24.2	2.3	14.9	1.20	6.4
Surplus (dollars per tonne)													
Over 250	22	709	28.1	36.4	17.1	75.7	0.23	299	26.1	2.3	17.4	1.52	5.8
200 to 250	21	953	23.0	19.0	19.0	78.1	0.24	237	28.6	2.7	15.3	1.50	6.5
160 to 200	22	696	35.8	18.2	17.9	46.8	0.38	196	26.9	2.3	18.8	1.51	9.6
Under 160	21	528	33.6	23.8	13.8	20.1	0.69	132	21.0	1.9	23.5	1.53	17.8

Sources:
Statistics Canada, National Accounts and Environment Division.
Environment Canada, Regulatory Affairs and Program Integration Branch.

Age and Modernization

The year that a mill was built does not necessarily dictate its efficiency or its pollution abatement except for mills which were built since 1971 when the first federal regulations came into effect. This fact is illustrated by the very low ACR (2%) for mills built since 1971 compared to 8.5% for mills built between 1900 and 1971. Those built prior to 1900 must spend, on average, 7% of annual surplus to be in compliance. It is interesting to note that the surplus per tonne of capacity was almost the same for recent mills and older mills, confirming that the actual age of the mill is not an important variable in profitability.

On the other hand, if modernization can be equated to a high level of investment averaged over the last 12 years then mills with above average investment might be expected to perform better and generate less pollution. This tendency exists to some extent as the surplus per tonne of capacity was $230 for high investors compared to $224 for low investors. The latter group of mills have a much smaller capacity (535 tonnes compared to 1052 tonnes per day). Although the mills with above average investment have a higher percentage of secondary treatment facilities (32% compared to 20%) their BOD factors are slightly higher. This reflects the fact that the smaller mills are less likely to produce their own pulp. Both groups of mills must spend 8% of their surplus annually to comply with the regulations, indicating that higher investment did not generally put mills in a better position with respect to compliance costs.

Product

The indicators by product category are very uneven, reflecting the underlying production processes and the presence of secondary treatment facilities. This latter variable, however, seems to be linked to the type of process. For instance, half of the producers of market kraft pulp in this sample have secondary treatment facilities yet their capital costs per tonne of product are higher than those of other paper and board mills, 11% of which have secondary facilities. Since the latter generally do not produce their own pulp, their BOD factors are low.

Although the AEI is much below average for mechanical pulp mills, these mills have one of the highest ACRs due to relatively high operating costs and a lower than average surplus per tonne of product. By far the highest compliance costs per dollar of surplus have been estimated for mills producing sulphite, semi-chemical or dissolving pulps. These mills generate a very high level of BOD and have a lower than average percentage of secondary facilities. Their required capital costs per tonne of product are three times the average and their surplus per tonne is 30% less than the average. These factors result in an ACR of 33% for the 9 mills in this category. These mills have an important impact on other characteristics in Table 3.

Region

Regionally, Quebec producers face the highest absolute compliance costs but they also produce more pulp and paper than those in other regions. Quebec mills account for 44% of the total capital costs of compliance but in terms of costs per dollar of surplus, mills on the Pacific coast[1] are the most affected. Average capital costs per mill in Quebec are estimated at $27 million, or about 1.7 years of AEI compared to 1.9 years for British Columbia coastal mills and only 0.4 years for mills in the Prairie provinces.

For the ACR, the pattern is similar although the differences between the regions are less marked. Mills in the Prairie provinces and the interior of British Columbia must spend 3% of surplus annually while mills on the Pacific coast must devote 10%. According to this measure there is little difference between mills in Eastern Canada despite the fact that Quebec has the lowest percentage of mills already equipped with secondary treatment facilities. The relatively low average surplus per tonne of product during the eighties in the Atlantic provinces and in the British Columbia interior mills increases this measure compared to other regions. In contrast, the above average surplus in Ontario reduces the relative impact of compliance costs in this province.

Control

The average capital and operating compliance costs are much the same for Canadian and foreign controlled mills yet the former were somewhat less profitable and thus had higher compliance costs relative to surplus. The 54 Canadian controlled mills had an AEI of 1.8 compared to 1.2 for the 32 foreign controlled mills.

The ratio of average investment to average surplus is very similar for both groups despite the higher surplus per tonne of product for the foreign controlled mills. (As shown in Table 3 for all mills considered here, there is generally an inverse relationship between level of surplus and this ratio). Average investment is indeed larger for foreign controlled mills but they are also larger and the investment per tonne of capacity is similar. There is no indication, therefore, that foreign controlled mills are less inclined to reinvest their earnings. On the other hand, the higher percentage of secondary treatment in foreign controlled establishments does not necessarily reflect a higher expenditure on pollution abatement. It would be necessary to examine the historical ownership records to determine this.

1. It is important to distinguish between B.C. coastal and interior mills because of the marked difference in their circumstances. Most interior mills had already acquired secondary treatment facilities whereas the coastal mills were relatively unequipped. Furthermore, due to the limited area surrounding coastal mills, it is necessary for many of them to use the activated sludge treatment process which is more costly.

Mills in Compliance

The mills that are deemed to have no costs resulting from the 1992 federal regulations on traditional pollutants are smaller, less profitable and had a higher investment per tonne of production than those for which such expenditures were assessed (Table 4). The low surplus per tonne of these mills seems to be mainly related to their product. These mills do not, by and large, produce newsprint or kraft pulp, products that generated a relatively high surplus per tonne during the eighties.

Table 4: Characteristics of Mills With and Without Compliance Costs

	With compliance costs	Without compliance costs
Number of mills	86	25
Average capacity (tonnes per day)	721	408
Average surplus (dollars per tonne)	210	169
Average investment (dollars per tonne)	64	104
Number with secondary facilities (percent)	24	48

Sources:
Statistics Canada, National Accounts and Environment Division.
Environment Canada, Regulatory Affairs and Program Integration Branch.

CONCLUSIONS

On average, mills not in compliance with the new federal regulations must spend an estimated 8% of operating surplus annually to purchase and operate the required treatment facilities. This percentage is inversely correlated with the production capacity of the mill and is strongly related to the type of product and the amount and type of pollution abatement equipment already in place. Although Eastern Canadian mills are often singled out as being old and less efficient, of the mills considered it is the British Columbia coastal mills that must devote the largest percentage of their surplus to this type of expenditure. For mills built before 1971, neither the age of the mill nor the level of investment over the last 12 years explains much of the variation in this percentage. Foreign controlled mills tended to perform better than Canadian controlled mills and had a higher percentage of secondary facilities already operational in 1989. These factors resulted in the former mills having a lower compliance cost per dollar of surplus.

Using average surplus as a denominator in the above measure gives an interesting perspective on the relative burden of compliance costs. Clearly, however, the performance of mills during the eighties is not necessarily a good predictor of their performance during the nineties, when the expenditures will have to be made. The high price of market pulp contributed substantially to surplus in the latter part of the decade. According to McCubbin (1990, p. 68), "the highest concentration of vulnerable mills is in the province of Quebec. All such mills are typified by high production costs, dated equipment vintage and high compliance costs." We have shown, however, that Quebec mills performed better than average during the eighties and invested a proportion of surplus equivalent to the average of all mills considered. The ACR in Quebec was only one percentage point higher than the general average. This potential contradiction illustrates one of the hazards of comparing estimated future costs to actual historical financial data. In the final analysis, however, there is no significant difference in the average surplus per tonne of product for mills that have both primary and secondary facilities, those that have only primary facilities or those that have none, a fact that suggests that pollution abatement costs have not detracted from the performance of pulp and paper mills in the past.

DATA SOURCES AND MEASUREMENT PROBLEMS

The following data files were used for this study:

Pollution Data

Information on BOD factors and treatment facilities came from the Pulp and Paper Mill Profile System described in Statistics Canada (1992, p. 96). The data pertain to 1989. This database contains information on 124 direct discharge mills.

Estimated Compliance Costs

As noted in the text, these data come from a report prepared for Environment Canada by N. McCubbin Consultants Inc. The report states that:

> "The approach of calculating estimates for each mill was selected as the best way of estimating the total costs for each industry sector and geographic region. Clearly, such estimates can never be as reliable as those based on detailed engineering analysis, flowsheets, site layout, soils studies and contractors bid prices. Several capital cost estimates were checked against independent estimates based on detailed studies, and were found to be within 20% of the latter costs. Some extreme mills are bound to exist where the individual costs estimated for this report are either excessive or inadequate. However, it is considered that the aggregate of any reasonably sized sub-set of mills (such as Quebec newsprint mills) is accurate within 20%" (McCubbin, 1990, p. 56).

Manufacturing Data

Records from the manufacturing survey for individual mills classified to SIC 271 were processed to obtain 1989 production figures by type of product. Surplus was calculated for the period 1981-1989 by subtracting the cost of materials, fuel and labour from the value of shipments. As noted in the text, this value is equivalent to operating profit

before depreciation and depletion allowances except that it includes head office expenses. Since the study considers individual mills, it was not possible to derive a net profit estimate at this level. A weighted average of the annual surplus was calculated using the GDP implicit price deflator.

Investment Data

It was possible to obtain investment data dating back to 1979 from the Capital and Repair Expenditure Survey conducted by Statistics Canada. Although data exist prior to this year, it would have been difficult to match individual mills. Averages were computed using the price indexes for capital expenditure on plant and equipment for paper and allied industries.

Record Matching

The matching of company names by location was relatively straightforward, especially with the help of the *Pulp & Paper Canada Annual* for 1989. In some cases one source reported data on a combined basis whereas other sources reported on the individual establishments. Mills for which all data were not available were omitted from parts of the analysis. This problem explains the variance in the number of mills reported. For instance, in Table 4 only 111 of the 124 direct discharge mills could be matched to combine information on surplus and investment. In Table 3 only 86 of the 94 mills reported as having compliance costs could be matched to show all the variables.

Variance

The variance about the mean is quite high in many cells of the tables presented in this study. Although excluding the outliers would have an effect on the mean in some cases, the difference is not large enough to change the conclusions. It should be noted, however, that the measures for a mill in any given category may be quite different from the average.

REFERENCES

Department of Fisheries and Oceans. “Pulp and Paper Effluent Regulations.” *Canada Gazette*, *Part I*, December 14, 1991.

Environment Canada. *The State of Canada's Environment.* Ottawa, 1991.

Headlam, B. and M.Stevenson. “Winning the Paper Chase.” *Canadian Business*, June 1990, p. 43.

Jamieson, Scott. “Airing Some Concerns: The Next Wave in Pollution Control.” *Pulp & Paper Canada,* 92, 10 (October 1991): 12-13.

McCubbin, Neil. “Economic Impact of Proposed Regulation of Pulp and Paper Industry.” (Unpublished.) Prepared for Regulatory and Economic Affairs Division, Environment Canada, June, 1990.

Pulp & Paper Canada. *1989 Annual and Directory.* Southam Business Publications. St.-Laurent, Quebec, 1989.

Sinclair, William F. *Controlling Pollution from Canadian Pulp and Paper Manufacturers: A Federal Perspective.* Environment Canada, 1990.

Statistics Canada. *Databases for Environmental Analysis: Government of Canada.* Occasional, Catalogue 11-527, Ottawa, 1992.

4 Transportation of Dangerous Goods

by Marcia Santiago

INTRODUCTION

Cargo transportation is an essential element of economic activity. The transportation system itself — roads, railways, pipelines and seaways — is a tangible link between industrial production and the consumer population.

Many aspects of transportation are associated with some level of environmental impact, including fossil fuel consumption, land use change and pollution from both the vehicles and people that use the transportation network. These may be measured in terms of either energy and material consumed or substances released into the environment. Other aspects of transportation, such as environmental risk, are not so easily quantified. This is because risk to the environment is quite different in nature from impact. The potential for impact is substantially more difficult to describe than an actual or realized effect. It is, nonetheless, a dynamic element of the relationship between the human and physical environments.

This chapter examines the regulation concerning the transport of dangerous goods in Canada. This is followed by the presentation and discussion of a variety of data on the tonnage of dangerous goods moved by various modes of transport, and on accidents involving dangerous goods. These two sets of data are used to estimate some simple indicators of the risk of accidental release of material associated with transportation of dangerous goods.

TRANSPORT REGULATIONS

In a practical sense, risk in transportation is usually understood in terms of human safety. Transportation is regulated on two levels: in the economic or competitive context, as well as in terms of safety. Safety is one of the main objectives of the National Transportation Policy (National Transportation Act 1987).

Dangerous goods are encountered in many economic activities, notably in many basic resource industries. In various forms, they are involved in virtually all types of manufacturing. Many are not intrinsically dangerous to the physical environment. In fact, most are regulated on the basis of their potential danger to transportation safety and human health. The term "dangerous goods" may, as such, be misleading in an environmental context but it is used in this chapter because it is the regulatory term of reference.

In Canada, the movement of dangerous goods is largely controlled through the federal Transport of Dangerous Goods Act (1985) and its associated Regulations (1985, 1989). This legislation applies to all domestic and international movements of dangerous goods by Canadian carriers.

Within this context, dangerous goods are those commodities recognized by the Act as "any product, substance, or organism included by its nature or by the regulations in any of the classes listed in the Schedule" to the Act. This schedule contains over 3 000 commodities, which are classified by United Nations Product Identification Numbers (PIN). These dangerous goods are aggregated into nine classes which form the basis of specific regulatory measures. Dangerous goods are controlled at all stages of transport: labelling of shipments, identification of hazardous substances on bills of lading and cargo manifests, and marking of vehicles. These regulations also stipulate training of anyone handling, offering to transport, or transporting dangerous goods.

THE ECONOMIC CONTEXT

Table 1: Dangerous Goods Transported, by Mode of Transport, 1986

Class	Rail	Road	Marine
	thousand tonnes		
1. Explosives (potentially explosive material)	51	115	14
2. Compressed or liquefied gases	5 647	1 158	246
3. Flammable and combustible liquids	3 748	18 186	10 283
4. Flammable and combustible solids	117	359	283
5. Oxidizers and organic peroxides	645	1 562	155
6. Poisonous and infectious substances	99	246	111
7. Radioactive materials	–	34	17
8. Corrosive materials	3 435	1 372	921
9. Miscellaneous dangerous substances or articles	2 047	401	99
Total	**15 790**	**23 433**	**12 129**

Sources:
Transport Canada and Statistics Canada (OECD, 1988)

Table 1 shows that, overall, road transport accounts for 46% of the dangerous cargo tonnage shipped[1]. Shipments by rail and by marine carriers account for 31% and

1. The relative importance of various modes in dangerous goods movement varies with the method of estimating levels of activity. For example, the comparison between trucking and marine shipments may produce different results depending on whether or not the distance travelled is associated with the quantity of freight (i.e., tonne-kilometres vs. tonnes). Rail and road data are qualified in the following sections. For marine shipments, the figure shown is for international movements only; the tonnage of dangerous goods for domestic shipping is not available.

24%, respectively. Flammable and combustible liquids (Class 3 substances) are the dangerous goods most commonly transported, representing 63% of the total weight of dangerous goods shipments. In terms of the mode of transport, flammable and combustible liquids represent 85% of international marine, 78% of for-hire trucking and 24% of rail shipments of dangerous goods.

Rail Movements

Dangerous goods represented 9%, by weight, of all commodities transported by rail within Canada and across the Canada-U.S. border in 1989. Domestic shipments of dangerous goods amounted to 11 million tonnes (or 68% of the total weight of dangerous goods shipments) and 181 thousand carloads (or 72% of total carloads shipped). Trans-border shipments contributed the remainder, at 5 million tonnes and 69 thousand carloads. These movements are summarized, by origin and destination, in Table 2.

Differences in unit weight (that is, the average weight per carload) across rail corridors may be attributed to a number of factors. High unit weights (e.g., 74 tonnes per car for domestic movements originating in Alberta) may indicate that the dangerous goods carried mainly consist of heavy, bulk materials. These would include crude petroleum oil or semi-refined petroleum products. Lower unit weights might suggest that the commodities being transported are more refined and less dense products. Low unit weights may also indicate that dangerous goods are being carried in mixed carloads with other, non-regulated products.

One fifth of rail movements in dangerous goods (representing 4 million tonnes and 49 thousand carloads) took place within provincial boundaries. Interprovincial shipments totalled 7 million tonnes (42%) and 195 thousand carloads. Alberta, Ontario and Quebec accounted for most of the activity.

Six products account for 44% of the dangerous goods tonnage transported by rail from the U.S. Ranked highest, in terms of tonnage, is sodium hydroxide (81 thousand tonnes, Class 8). In this group, there are also two Class 3 commodities: cyclohexane (74 thousand tonnes) and benzene (27 thousand tonnes). Isobutylene (71 thousand tonnes) and propylene (65 thousand tonnes) are both Class 2 substances. One commodity, ethylenediamine tetra-acetic acid (EDTA), is classified by Transport Canada as an environmentally hazardous substance (Class 9.2, 44 thousand tonnes).

Similarly, among rail shipments of dangerous goods from Canada to the U.S., five products account for half of the tonnage. Three of these are compressed or liquefied gases (Class 2): ammonia (902 thousand tonnes), isobutane (396 thousand tonnes), and propane (313 thousand tonnes). Asbestos (473 thousand tonnes, Class 9) and sulphuric acid (468 thousand tonnes, Class 8) are also substantial components of the activity.

Table 2: Rail Movement of Dangerous Goods, by Origin and Destination, 1989

Origin	Destination: Nova Scotia and New Brunswick	Quebec	Ontario	Manitoba and Saskatchewan	Alberta	British Columbia and the Territories	United States	**Total**
	thousands of tonnes transported / *carloads*							
Nova Scotia and New Brunswick	278	24	55	3	2	1	12	**375**
	4 136	*1 035*	*2 119*	*110*	*122*	*55*	*214*	***7 791***
Quebec	289	577	227	57	65	51	737	**2 003**
	5 985	*8 033*	*5 361*	*1 660*	*2 086*	*1 407*	*10 137*	***31 579***
Ontario	227	942	1 323	209	318	254	1 601	**4 875**
	7 266	*14 223*	*17 689*	*7 313*	*10 396*	*7 785*	*21 653*	***86 325***
Manitoba and Saskatchewan	16	5	181	257	8	36	172	**676**
	215	*151*	*2 856*	*3 907*	*233*	*588*	*2 457*	***10 407***
Alberta	53	255	530	292	721	2 329	2 490	**6 668**
	813	*3 172*	*6 404*	*4 117*	*9 775*	*28 926*	*32 094*	***86 111***
British Columbia and the Territories	--	5	12	7	32	577	47	**679**
	2	*200*	*4 833*	*147*	*522*	*7 794*	*672*	***9 896***
United States	2	183	342	29	121	82	62	**821**
	94	*4 967*	*36 821*	*507*	*1 793*	*1 026*	*785*	***14 005***
Total	**865**	**1 990**	**2 670**	**853**	**1 268**	**3 331**	**5 119**	**16 097**
	18 421	***31 781***	***39 821***	***17 761***	***24 927***	***47 581***	***68 822***	***249 114***

Source:
Statistics Canada. *Rail in Canada 1989.* Catalogue 52-216.

Road Movements

As in other industrial economies, road transport accounts for most of the dangerous cargo shipments within Canada (OECD, 1988). This reflects, to a great extent, the prominence of for-hire trucking in local freight distribution.

Table 3 is a summary of interprovincial dangerous goods movement by for-hire trucking in 1989. Shipments between and within urban areas account for 40% (1.9 million) of the shipments and 23% (7.7 million tonnes) of the weight transported. About 244 thousand shipments are made within Toronto's Census Metropolitan Area (CMA), the greatest number of dangerous goods movements within an urban centre. The greatest concentration of tonnage is transported within the Vancouver CMA, which accounts for 1.7 million tonnes of dangerous goods. Transborder activity accounted for 2% of shipments and 5% of dangerous goods tonnage. Compared to transborder rail movements, this is a considerably lower proportion of activity.

ACCIDENTS

Over time, the overall frequency of transportation accidents has tended simply to reflect the level of shipping activity. In 1991, the Transportation Safety Board reported a decrease in air and marine accidents compared to the previous year (TSB, 1992). In the same time period, there was an increase in the number of rail accidents but the accident rate actually declined somewhat (TSB, June 1992).

The pattern of transportation accidents that involve dangerous goods is also tied to the level of activity. Overland shipments account for most of the dangerous tonnage transported and it follows that the road and rail modes also account for most of the accidents involving dangerous goods (Table 4).

The likelihood of an accident may also be expressed, for either overland mode of transport, in terms of the total shipments. Among rail movements, it is estimated that one accident occurs for every 545 carloads, or 36 thousand tonnes, of dangerous goods transported. In for-hire trucking, the probability of accident is estimated at one in 21 thousand truckloads, or 70 thousand tonnes, of dangerous goods transported.

Between classes of dangerous goods, the occurrence of accidents is only weakly correlated with the quantities transported. In rail shipments, Class 3 substances account for 24% of the tonnage and 29% of the accidents (one accident for every 29 thousand tonnes transported). In road movements, these commodities account for 78% of the tonnage and 43% of the accidents (one accident for every 90 thousand tonnes transported).

An important dimension of any accident involving dangerous goods is whether or not material release occurs as

Table 3: Dangerous Goods Handled in For-hire Trucking, by Origin and Destination, 1989

	Destination								
Origin	Newfoundland and Prince Edward Island	Nova Scotia and New Brunswick	Quebec	Ontario	Manitoba and Saskatchewan	Alberta	British Columbia and the Territories	United States	**Total**
	thousands of tonnes / *thousands of truckloads*								
Newfoundland and Prince Edward Island	163	25	1	--	--	33	--	--	**223**
	18	*3*	--	--	--	*1*	--	--	***22***
Nova Scotia and New Brunswick	50	2 400	39	14	--	--	--	220	**2 725**
	7	*195*	*5*	*5*	--	*1*	*1*	*8*	***233***
Quebec	9	107	3 308	684	12	23	7	148	**4 299**
	4	*32*	*495*	*335*	*11*	*14*	*11*	*11*	***913***
Ontario	9	90	688	6 632	71	56	20	546	**8 113**
	11	*55*	*316*	*1 735*	*39*	*34*	*27*	*41*	***2 259***
Manitoba and Saskatchewan	--	4	5	176	2 983	214	47	293	**3 721**
	--	*1*	*2*	*29*	*245*	*29*	*7*	*11*	***325***
Alberta	--	--	11	40	949	6 810	924	264	**8 998**
	--	*1*	*3*	*9*	*62*	*402*	*68*	*13*	***557***
British Columbia and the Territories	--	7	4	16	26	793	3 392	124	**4 362**
	--	*1*	*3*	*8*	*6*	*45*	*297*	*9*	***367***
United States	2	19	139	492	53	73	60	8	**845**
	1	*4*	*21*	*75*	*9*	*11*	*9*	*2*	***131***
Total	**234**	**2 652**	**4 195**	**8 054**	**4 094**	**8 003**	**4 450**	**1 604**	**33 287**
	52	***291***	***845***	***2 196***	***372***	***372***	***419***	***96***	***4 808***

Source:
Statistics Canada. For-hire Trucking (Commodity Origin-Destination) Survey.

Table 4: Transportation Accidents Involving Dangerous Goods, 1990

Class	Total accidents					Accidents with material release				
	Road	Rail	Marine	Air	**Total**	Road	Rail	Marine	Air	**Total**
1. Explosives (potentially explosive material)	9	4	-	-	**13**	2	1	-	-	**3**
2. Compressed or liquefied gases	63	193	-	-	**256**	44	105	-	-	**149**
3. Flammable and combustible liquids	203	131	3	8	**345**	194	67	3	7	**271**
4. Flammable and combustible solids	15	10	-	1	**26**	14	1	-	1	**16**
5. Oxidizers and organic peroxides	11	15	-	-	**26**	8	4	-	-	**12**
6. Poisonous and infectious substances	44	14	1	3	**62**	42	9	1	2	**54**
7. Radioactive materials	4	-	1	1	**6**	1	-	-	-	**1**
8. Corrosive materials	99	74	2	1	**176**	94	39	2	1	**136**
9. Miscellaneous dangerous substances or articles	13	4	-	1	**18**	12	3	-	1	**16**
n.e.s	16	7	1	-	**24**	15	5	1	-	**21**
Total	**477**	**452**	**8**	**15**	**952**	**426**	**234**	**7**	**12**	**679**

Source:
Transport Canada. Dangerous Goods Directorate.

a result of the accident. With the data provided in Table 4, it is difficult to ascertain whether material release in accidents is related to mode of transport. Overall, 71% of all accidents that involve dangerous goods do result in material release. By relating the frequency of material release to the number of accidents, there would appear to be many more accidents with material release by road transport (89%) than by rail (52%). However, in terms of the tonnage of cargo transported, rail and road shipments have about the same probability of material release; there is about one accident in which material is released for every 70 thousand tonnes of material transported.

Simple frequencies cannot truly depict the magnitude of the impact that results from the accidental release of dangerous cargo. For example, in the summer of 1991 an accident provoked the derailment of twenty-five cars in St. Lazare, Manitoba (TSB 1992). Ten were carrying dangerous cargo and four of those ruptured. A toxic cloud was released, which contained methanol and acetic anhydride, and village residents were temporarily removed from the area.

HAZARDOUS WASTE

Class 9 substances, which are described as miscellaneous dangerous substances or articles, constitute a very small proportion of the total shipments and accidents involving dangerous goods. This category also includes hazardous waste such as PCBs (Table 5). Despite their minimal contribution to the total shipments of regulated substances, these commodities receive a great deal of public attention. Such a high profile is likely related to perceptions of the probability of accidents and spills, as well as the risks to health, safety and the environment that are believed to be associated with hazardous waste.

Table 5: Rail and Road Movements of Class 9 Substances, 1992

Class	Movements				Average distance
	Rail		Road		
	thousand tonnes	cars	thousand tonnes	trips	km
9.1 Miscellaneous dangerous goods	1 053	17 824	485	67 076	818
9.2 Environmentally hazardous substances	496	7 819	44	6 573	620
9.3 Dangerous wastes	2	42	..	..	..
9.9 Other	977	38 149	...	...	...
Total	**2 528**	**63 834**	**530**	**73 649**	**800**

Source:
Transport Canada. Dangerous Goods Directorate

Rail shipments of hazardous waste in 1992 were estimated at about two thousand tonnes or 42 cars, representing less than one tenth of one percent of Class 9 freight in this mode. Furthermore, Class 9 materials were involved in a very small proportion of the accidents involving dangerous goods. Among accidents involving dangerous goods

where material was released, only 2% involved Class 9 cargo.

There is a great deal of discussion regarding the risks associated with storing, handling, and transporting hazardous waste. Some perceive that the transport of hazardous waste poses a greater health and safety risk than that of other classes of dangerous goods. Others believe that accidents involving hazardous waste are more likely to occur in transportation than in storage and handling or after equipment failure. There is one study, for the province of Manitoba, where it has been shown that the risk of accident in transportation is no greater than in any other activity involving hazardous waste (Manitoba Environment, 1991). It is difficult, however, to compile complete, reliable data and, therefore, to arrive at firm conclusions.

The risks associated with hazardous waste transport are difficult to ascertain. Among rail movements, the likelihood of an accident involving a Class 9 substance is estimated at one in 16 thousand carloads, or one in 632 thousand tonnes. Compared to the accident rate among dangerous goods, in general, this probability is considerably lower. Among road movements, it is estimated that one accident occurs for every 6 thousand shipments, or 41 thousand tonnes, of Class 9 substances. Based on these data, there is one accident for every 33 thousand tonne-kilometres of dangerous goods transported by road. It should be noted, however, that the estimates of shipment frequency and tonnage for road movement are based only on for-hire trucking whereas statistics on accidents cover all trucking. Thus, the probability of accidents may be overstated.

DATA SOURCES

By law, dangerous goods movements are monitored through a system of permits but, despite this requirement, there is no central source of data.

Data for rail shipments are collected by the Dangerous Goods Directorate of Transport Canada from the Canadian National and Canadian Pacific Railways. Data for the period 1987-1989 were supplied by Transport Canada to Statistics Canada for special studies on dangerous goods movement, which appeared in *Rail in Canada 1988* and *1989* (Catalogue 52-216).

The Transportation Division of Statistics Canada maintains databases on for-hire trucking. With the assistance of Transport Canada, commodities designated as being "dangerous" under the Act are identified on this database. A similar exercise is being undertaken with international shipping data. In all cases, estimates of dangerous goods shipments are based on bills of lading, cargo manifests or their equivalent; none are based on dangerous goods permits. At present, no data are available for the following types of shipments: own-account trucking, rail movements other than CN and CP, domestic shipping and permits for exception in all modes.

The data derived from bills of lading are coded by either the Standard Trade Commodity Classification or the Harmonized Commodity Description and Coding System. Neither corresponds precisely to the PIN classification and the estimates of movements of dangerous goods require adjustments. For example, in rail movements, Class 9.9 was created for mixed cargoes of regulated and non-regulated commodities.

REFERENCES

Manitoba Environment. *State of the Environment: Report for Manitoba, 1991.* Winnipeg, 1991.

Organization for Economic Cooperation and Development (OECD). *Transporting Hazardous Goods by Road.* Report prepared by an OECD Scientific Experts Group. Paris, 1988.

Transportation Safety Board of Canada (TSB). *Annual Report 1991.* Ottawa, 1992.

-----. *Summary of Railway Accidents/Incidents,* Ottawa, June 1992.

5 Land Use Change Around Riding Mountain National Park

by Douglas Trant

INTRODUCTION

Riding Mountain National Park has been described as:

> "An island of natural environment surrounded by a sea of man-altered environment. The transition zone from farmlands is illustrated dramatically by the wheat fields and pastures abutting the natural environment."
> (Parks Canada, 1987).

The park is a unique area of Canadian wilderness where habitats characteristic of eastern, western and northern Canada converge in a series of forests, grasslands, hills and valleys. Riding Mountain National Park's 3 000 square kilometre area is home to 5 000 elk, 4 000 moose, and over 1 000 black bears. Many other species such as wolf, beaver, cougar and osprey also inhabit this nature reserve. In summer months more than 30 000 people visit the park each weekend.

Riding Mountain National Park is located on the Manitoba Escarpment, and can be described as an elevated boreal island surrounded by prairie. Because of its unusual combination of attributes it was designated as an International Biosphere Reserve, as part of the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Man-Biosphere Program. UNESCO established the Man-Biosphere Program in 1971 to ensure the preservation of unique natural environments in each of the world's biogeographic regions. A Man-Biosphere reserve typically consists of a protected core of natural environment together with adjacent areas which collectively form a zone of co-operation. The Man-Biosphere Program recognizes that socio-economic activities and natural ecosystems must co-exist in an effort to guarantee the survival of both. Some 266 Man Biosphere Zones have been selected globally to date.

In recent years the transition zone from park to agriculture has become narrower, making the likelihood of conflict between activities more probable. Close co-existence of agriculture and wilderness can induce conflict, as one interferes with the other. The survival of the nature reserve depends on careful organization, planning and management. The role of information to support decision-making in this process is important. The findings of this analysis and the information that supports it will be added to a larger inventory of data supporting the Biosphere Reserve Program at Parks Canada.

This study will examine the changing mosaic of socio-economic activity that surrounds Riding Mountain National Park. The inter-relation between park, biosphere reserve and beyond is explored from both spatial and temporal perspectives. Many Statistics Canada micro-databases have been tapped to generate a detailed profile of the area as it has evolved over the last twenty years. Most of these information bases are accessed through the National Accounts and Environment Division's Environmental Information System (EIS) which uses geo-referenced data within a geographic information system (GIS) framework.

This analysis is divided into three Sections. The first section provides background on the history of the park and focuses on issues that have emerged as human settlements and activities move closer to the park, placing more and more pressure on the nature reserve. This section will also describe the physical setting of Riding Mountain, by briefly looking at physiography, hydrology and important biotic communities.

The second section will look at changing population and land use trends around the park over the last twenty years. A detailed statistical profile consisting of a series of concentric zones around the park, will be used to indicate composite activity changes in relation to proximity to the park.

The third section examines changes in agricultural practices around the park. Trends in farm input levels and cropping practice changes will be examined over time to suggest potential effects on the park.

PHYSIOGRAPHY AND HISTORICAL BACKGROUND OF RIDING MOUNTAIN NATIONAL PARK

History

In the early 1800's the land that comprises Riding Mountain National Park was exploited largely as a timber resource for the construction of railways and farm buildings. In 1895, in response to continued pressure from growing settlements, the Dominion Government chose to set aside today's park area as a forest reserve. The purpose of this reserve was to continue to provide lumber to developing communities at controlled rates in an effort to maintain a continual long term supply of wood (Tabulenas, 1983, p. 175). As a new forest reserve, Riding Mountain came under the jurisdiction of the Forestry Branch of the former Department of the Interior. Husbandry of the reserve became the responsibility of foresters who controlled forest harvest rates. By the early 1900's increased de-

mands for lumber and uncontrolled hunting access had diminished wildlife populations to dangerously low levels. In response to public concern, the Manitoba Government enacted legislation to make Riding Mountain into a game reserve (Tabulenas, 1983, p. 191).

Despite the economic depression of the 1920's and early 30's, agriculture continued to expand and ultimately advanced to the very edge of the Riding Mountain Reserve. In response to this pressure, and a new public demand for leisure and recreational space, the Riding Mountain Preserve became a National Park in 1930. Since then two very different landscapes have evolved, and Riding mountain has become an island of wilderness within a sea of agricultural development (Tabulenas, 1983, p. 200).

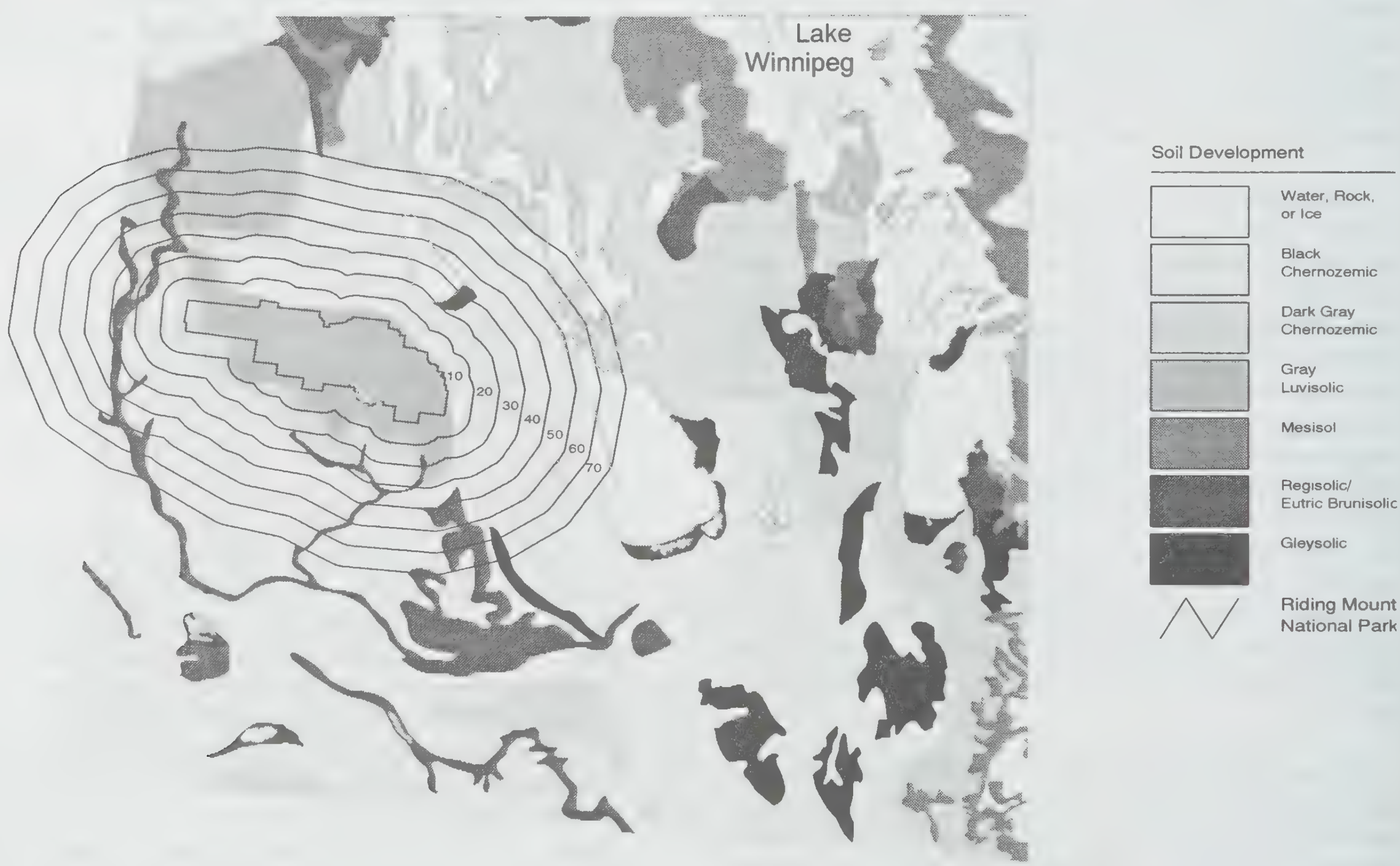
Physiography

Riding Mountain National Park straddles an upland plateau formed by the geologic faulting of the Manitoba escarpment and the subsequent deposition of glacial moraine landforms from the last glacial period some 12 000 years ago. The bedrock geology underneath the park and surrounding area is largely sedimentary, consisting of highly erodible shale types. The soils on Riding Mountain Plateau have developed from shale parent materials and are largely Grey Luvisols. These soils form in cool climates under woodland vegetation. (See map 1) The soils surrounding the Riding Mountain Plateau are largely Chernozems which form in cool climates under grassland vegetation. The Chernozems are quite fertile because of their high organic matter content and provide the soil base for a productive agricultural industry.

Hydrology

The Riding Mountain Plateau is the origin for many streams and rivers including the Wilson River, the Vermillion River, the Ochre River and the Turtle River. Flooding problems in these watersheds are not uncommon and are exacerbated by the build-up of shales in the stream network (Krawchuk, 1990, p. 113).The shale build-ups are primarily from erosion of alluvial fan material which has been disturbed by the recent clearing of land for agricultural use.

Map 1: Soil Types in Southern Manitoba



Notes:
Map 1 is from Agriculture Canada's 1:1 000 000 Soil Landscape Series. Riding Mountain National Park is outlined in black and is surrounded by a series of radial buffers which will form the basis for a socio-economic data analysis in the section Population and Land Use Characteristics.
Sources:
Agriculture Canada, Centre for Land and Biological Resources.
Statistics Canada, National Accounts and Environment Division.

Natural Vegetation and Ecological Communities

There are three distinct ecological communities within the Riding Mountain Biosphere Reserve. These are: Mixedwood Forest, Aspen-Oak Woodland and Grassland. The rough fescue prairie grassland within the park is of international significance as there are few undisturbed examples left in the world. (Most former fescue grasslands are now producing grain crops.) The hardwood forest community on the southern slopes of the park is also unique. This forest is growing 1 000 kilometres north of its traditional northern limit, and has survived because of the warm micro-climate created along the south facing escarpment (Krawchuk, 1990, p. 124).

POPULATION AND LAND USE CHARACTERISTICS

The land use and population study area is oval in shape and extends 250 kilometres in an east-west direction and 160 kilometres in a north-south direction. The study area represents more than 3.3 million hectares of park and surrounding farmland. A series of 10 km wide radial buffer zones have been developed to which micro-geographic data have been linked and aggregated[1]. Each radial zone around the central core represents an increasing area as the zones radiate away from the park. The 0-10 km zone is just under 320 thousand hectares while the 60-70 km zone is just under 656 thousand hectares. (See zone areas in Table 2 and Map 1.)

Rural populations have been declining in Manitoba and Saskatchewan for some years now. Manitoba's rural population declined by 1.9% between 1971 and 1986, while Saskatchewan's declined by 10.6%. The Riding Mountain area has experienced even sharper declines in population. (See Table 1 and Map 2.)

Table 1 indicates that rural population has declined by more than 21.6%, between 1971 and 1986. All zones showed a decline in rural population, zone 0-10 showed the smallest decline at 6.7%, and zone 20-30 showed the largest decline at 31.8%. These patterns indicate a declining farm population and an increasing trend towards living in urban centres.

Urban populations in the study area are quite small and exist primarily in zone 10-20 where the towns of Minnedosa and Dauphin are located. Zone 10-20 showed an urban increase of slightly more than 10.3%. Urban population for the study period grew by 16.4%. (See Table 1)

Changing demographic patterns around Riding Mountain reflect changing farm economics. Farm populations have been declining on the prairies for some time now. World grain prices have in part contributed to this decline. For example, in 1914, a tonne of wheat was worth \$468 (1991 dollars) on the world market; in 1990, a tonne of wheat sold for an average of \$113[2]. As the nature of farming changes in an intensely competitive international market, more and more rural dwellers move to urban areas. This trend is evident around Riding Mountain, as it is elsewhere in Canada.

Agriculture is the dominant land use activity around Riding Mountain National Park. Throughout the study period (1971-1986), agriculture has consistently occupied 80% of land around the park and directly provides almost a quarter of all employment in the study area. Table 2 describes farmland areas and changes in these areas as pro-

1. See Data Limitations section.

2. Statistics Canada, Canada Level Price Series, Agriculture Division, Farm Income and Prices Section, 1992.

Table 1: Change in Population, 1971 and 1986

Radial zone	Rural population 1971	Rural population 1986	Rural change in population 1971-1986	Urban population 1971	Urban population 1986	Urban change in population 1971-1986	Total population 1971	Total population 1986	Total change in population 1971-1986
	number		percent	number		percent	number		percent
0-10 km zone	6 090	5 685	-6.7	0	0	0.0	6 090	5 685	-6.7
10-20 km zone	11 920	8 650	-27.4	10 415	11 485	10.3	22 335	20 135	-9.9
20-30 km zone	8 120	5 540	-31.8	0	1 030	..	8 120	6 570	-19.1
30-40 km zone	9 000	7 465	-17.1	4 375	4 435	1.4	13 370	11 900	-11.0
40-50 km zone	8 620	6 930	-19.6	4 450	4 280	-3.8	13 073	11 215	-14.2
50-60 km zone	10 030	8 755	-12.7	0	0	0.0	10 030	8 755	-12.7
60-70 km zone	12 530	8 955	-28.5	0	1 160	..	12 530	10 110	-19.3
Total	**66 310**	**51 980**	**-21.6**	**19 240**	**22 390**	**16.4**	**85 550**	**74 365**	**-13.1**

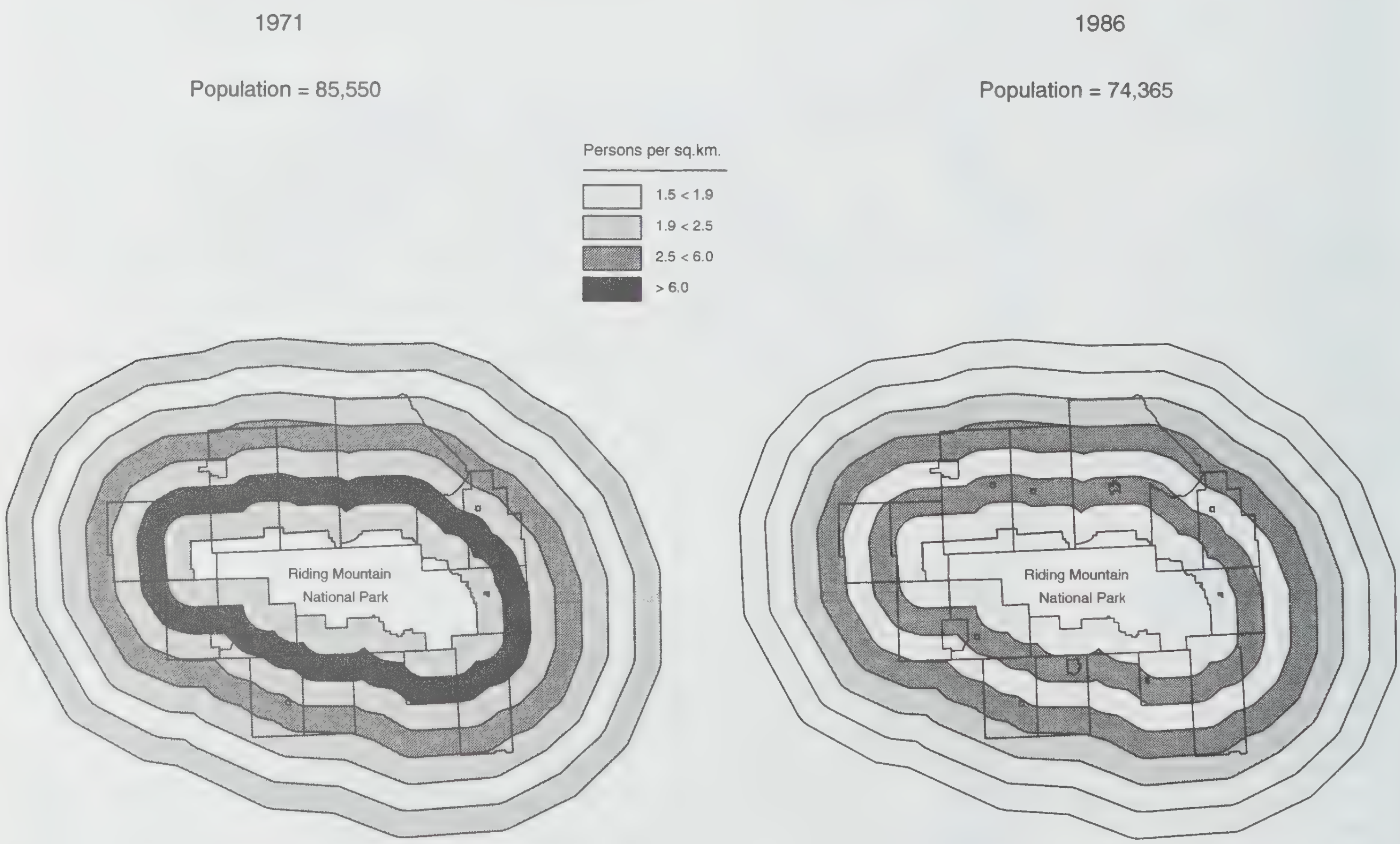
Notes:
10 kilometre radial buffers were used to classify data concentrically around Riding Mountain National Park.
Figures may not add to totals due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Table 2: Change in Farmland Area, 1971 - 1986

Radial zone	Zone area	Farmland area 1971	Farmland area 1986	Proportion of zone area in farmland 1971	Proportion of zone area in farmland 1986	Change in farmland area 1971-1986	Average farm size 1971	Average farm size 1986	Average farm size Change 1971-1986
	thousand hectares			percent			hectares		percent
0-10 km zone	320	246	297	76.8	92.7	20.7	191	263	38.0
10-20 km zone	354	316	273	89.4	77.1	-13.8	216	273	26.7
20-30 km zone	411	388	383	94.4	93.2	-1.3	257	324	26.1
30-40 km zone	471	343	340	72.7	72.1	-0.9	238	314	32.2
40-50 km zone	535	443	420	82.8	78.7	-5.0	292	360	23.5
50-60 km zone	595	411	455	69.0	76.5	10.8	264	354	34.4
60-70 km zone	656	487	467	74.3	71.2	-4.2	288	374	29.8
Total	**3 341**	**2633**	**2 634**	**78.8**	**78.8**	**0.3**	**249**	**323**	**29.8**

Note:
10 kilometre radial buffers were used to classify data concentrically around Riding Mountain National Park.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 2: Population Density, 1971 and 1986



Note:
Municipalities making up the Riding Mountain Biosphere Reserve are outlined around the park.
Source:
Statistics Canada, National Accounts and Environment Division.

portions of total area for the 7 radial zones between the 1971 and 1986 census years. (See Map 3.)

In brief, farmland area for the entire study area has essentially remained constant over the 15 year study period, showing an increase of less than 1%. However, significant changes have occurred when individual radial zones are examined. The 0-10 kilometre zone nearest the park shows the highest change where agricultural areas continue to expand. Farmland has increased by 20% in this zone, going from 77% of zone area to over 92%, making it second only to zone 20-30 at 93% agriculture. This trend indicates that the boundaries separating land use activities are becoming narrower and the likelihood of conflict between uses is therefore increased.

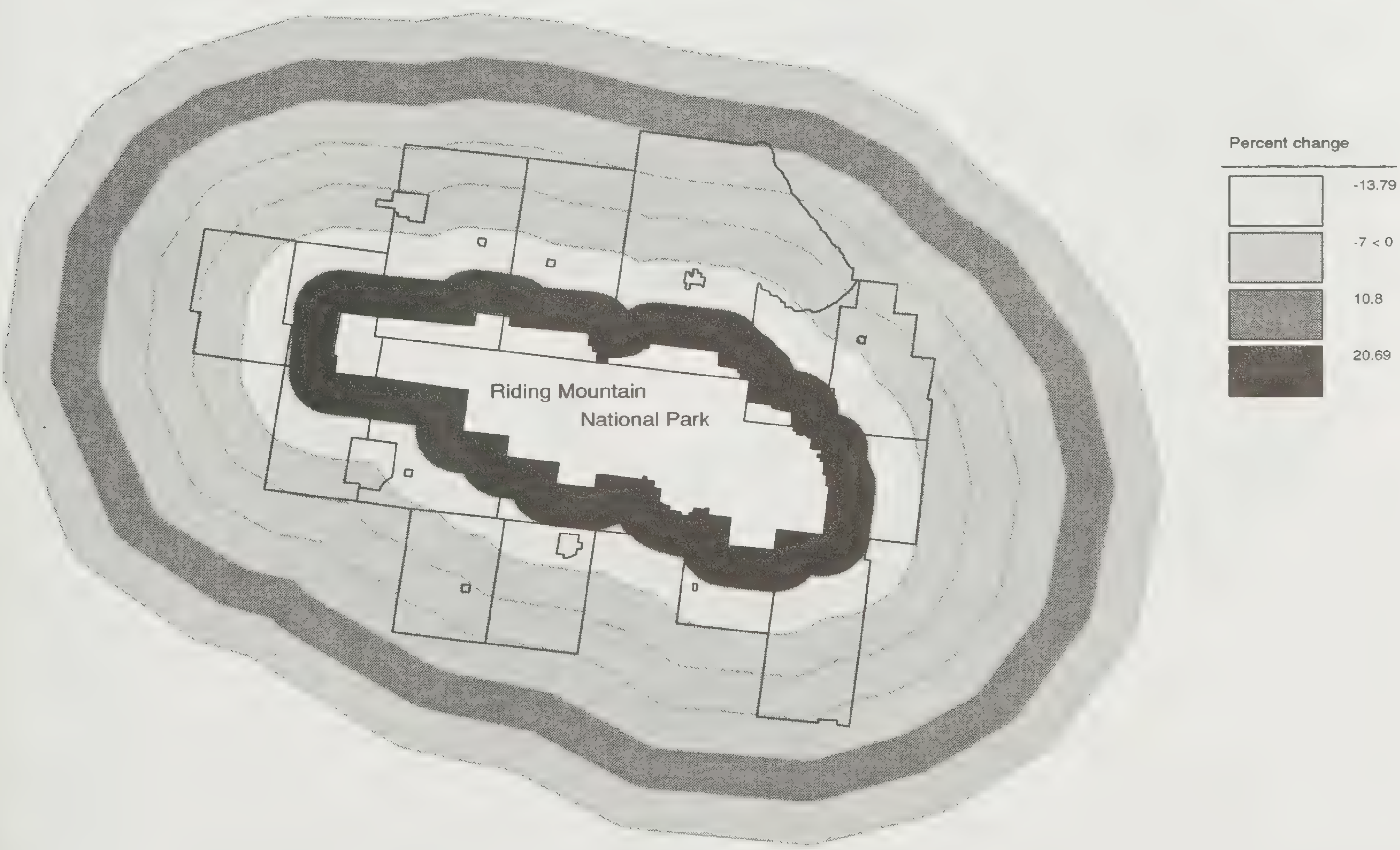
Idle land that used to form a cushion between activities is no longer there and the probability of having bears in farmers fields has increased as has the potential for animal poisoning by farm pesticides.[1]

Table 3 looks at the improved farmland[2] trends at varying distance from the park. Cropland trends are on the rise in all of the radial zones. The entire study area shows a 27.8% increase in cropland area. Since farmland areas in Table 2 have remained stable, and cropland areas in Table 3 are on the rise, it is apparent that a larger proportion of farmland is being placed in production and that land use intensity is increasing. Map 4 shows the radial distribution of cropland area changes around the park. The 0-10 zone shows the largest change with a 41.7% increase. Summerfallow areas are declining in all of the radial zones. The study area shows a decline of 43.8%. This is positive from a soil salinization perspective since the rate at which salinization occurs is dependent on soil moisture levels as they are affected by summerfallowing (Dumanski, 1986, p. 206). Summerfallowing contributes to salinization by raising soil moisture levels, and causing migration of stored salts.

1. Riding Mountain National Park warden Mac Estabrooks indicated, in a telephone conversation, that bear and elk were entering surrounding fields with increasing regularity.

2. Farmland that is considered improved can be cropland, improved pasture, summerfallow, or other improved land.

Map 3: Change in Farmland Area, 1971-1986



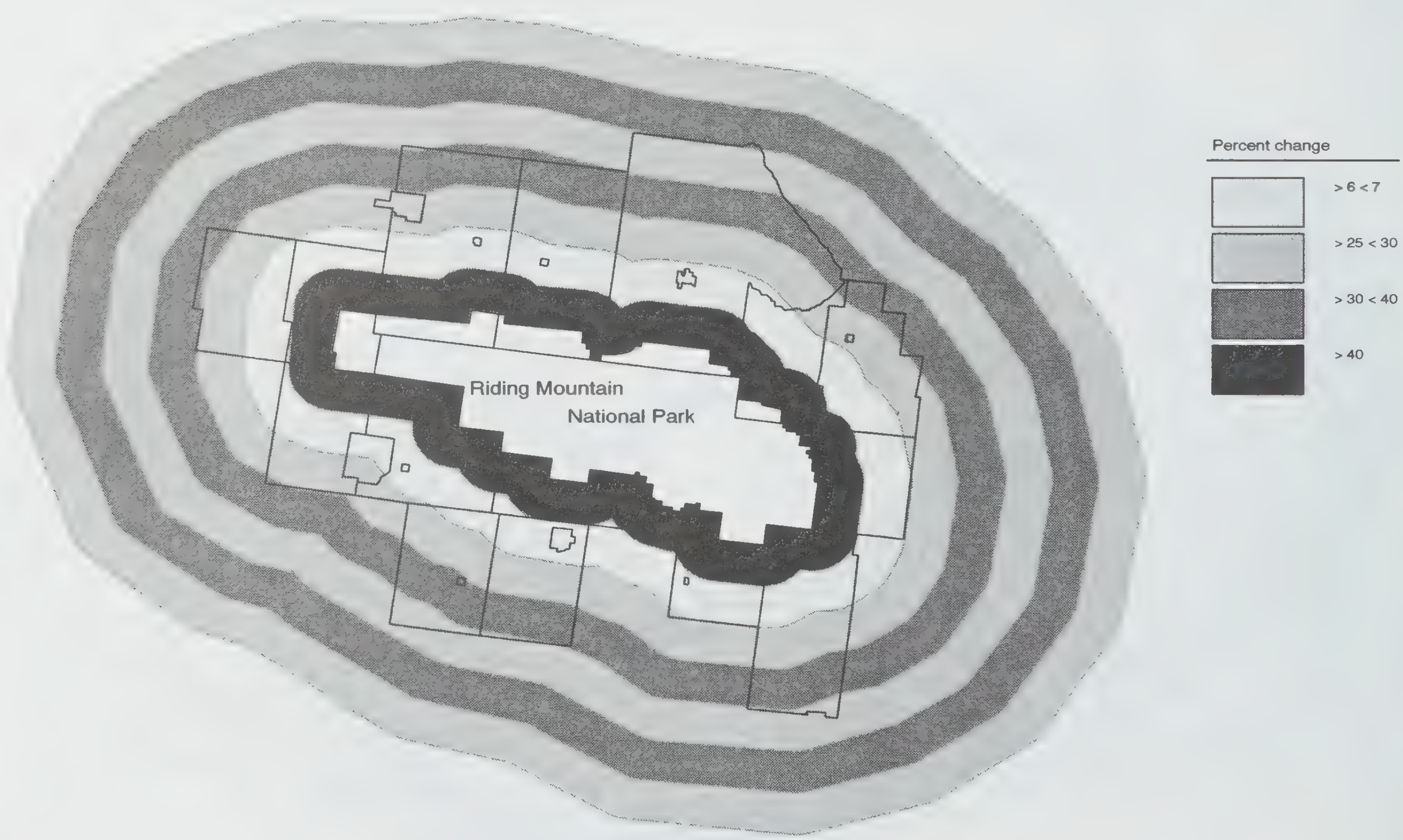
Notes:
Farmland change refers to change in proportion of zone farmland. Municipalities making up the Riding Mountain Biosphere Reserve are outlined around the park.
Sources:
Statistics Canada, National Accounts and Environment Division and the Census of Agriculture.

Table 3: Change in Improved Farmland Area, 1971-1986

	Improved farmland											
	Cropland			Improved pasture			Summerfallow			Other improved land		
Radial zone	1971	1986	Change 1971-1986	1971	1986	Change 1971-1986	1971	1986	Change 1971-1986	1971	1986	Change 1971-1986
	thousand hectares			thousand hectares		percent	thousand hectares		percent	thousand hectares		percent
0-10 km zone	107	151	41.5	9	15	58.3	46	34	-25.9	4	4	1.2
10-20 km zone	145	154	6.3	11	9	-15.9	58	30	-49.3	5	3	-36.8
20-30 km zone	150	192	27.5	15	18	17.0	67	34	-48.3	6	4	-32.0
30-40 km zone	141	184	30.2	8	9	8.2	70	35	-49.4	5	4	-17.6
40-50 km zone	159	203	27.7	22	27	22.0	70	41	-41.6	6	5	-16.3
50-60 km zone	157	211	34.6	17	14	-15.7	73	40	-44.8	6	5	-16.4
60-70 km zone	177	224	26.7	16	17	6.5	80	42	-47.6	6	5	-9.4
Total	**1 035**	**1 318**	**27.3**	**97**	**107**	**10.4**	**463**	**256**	**-44.7**	**37**	**30**	**-18.9**

Note:
10 kilometre radial buffers were used to classify data concentrically around Riding Mountain National Park.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 4: Change in Cropland Area, 1971-1986



Notes:
Cropland change refers to change in proportion of zone in cropland. Municipalities making up the Riding Mountain Biosphere Reserve are outlined around the park.
Sources:
Statistics Canada, National Accounts and Environment Division and the Census of Agriculture.

Table 4 depicts trends in unimproved farmland. These areas, with the exception of unimproved pasture, are showing significant declines. Woodland which is important to wildlife as cover, and as a food source, shows sharp declines in all of the radial zones. The zone closest to the park contains the highest proportion of farm woodland, of its 320 000 hectares 8 887 remained in farm woodland in 1986. (Some woodland still exists outside farmland areas but this amount must be less than 7.3% of the zone area, 92.7% of zone 0-10 is farmland.) Map 5 portrays the extent to which farm woodland areas have been declining around the park.

As human activities intensify and move closer to the park the likelihood of conflict increases. Agriculture-wildlife conflict can manifest itself in many different ways. For example, species such as the burrowing owl and prairie chicken can lose habitat to agriculture and be reduced in numbers or even disappear. Other birds such as the brown headed cowbird, thrive in a cleared cropland environment. These birds displace other species, such as the yellow warbler by reproducing in a parasitic manner, reducing the breeding success of other species (Environment Canada, 1991, p. 6-6).

Expanding agricultural land use further limits not only the diversity and numbers of wild animals, but that of plant life as well. Native plant communities are displaced and replaced by crop monocultures. (See below.) Even when land is later withdrawn from agriculture, the original grasses and wild flowers tend to be supplanted by hardier opportunistic weed species (Environment Canada, 1991, p. 6-6).

FARM INCOME, INPUTS AND AGRICULTURAL PRACTICES

The distribution of farm income per hectare of farmland around Riding Mountain appears to show a concentration of high income earners in the south on the black chernozemic soils, with lower incomes in the north on the luvisolic soils. (See Map 6 and Map 1.) Farmers in areas close to the park tend to have lower incomes, with the exception of some polygons[1] along the northern park boundary which are on dark grey chernozemic soils.

Agricultural practices have changed significantly on the Prairies over the last twenty years. As previous tables have indicated, fewer farmers are operating more farm area. In an effort to increase production and stay competitive, more farm inputs such as fertilizers, chemicals and fuels are being consumed than ever before. Bigger, more costly equipment is being purchased to operate larger and larger farms. Farmers have expanded their operations and have begun to rely on labour saving, capital intensive technology to operate these bigger farms. The environmental cost of these new technologies is substantial (Dumanski, 1986, p. 205).

Agricultural production in Canada has quadrupled in the last 60 years (Statistics Canada, 1991, p. 186). Farming methods and cropping practices have changed. Farms have become highly productive and are specializing in a narrower range of activities than ever before. Farms are

1. The spatial units (polygons) in Map 5 are generated from enumeration area centroid points. Thiessen polygons are created around each centroid using a "nearest neighbor function". Lines between points are bisected at the mid-point to form continuous boundaries around each point.

Table 4: Change in Unimproved Farmland Area, 1971-1986

	Unimproved farmland								
	Unimproved pasture			Woodland			Other improved land		
Radial zone	1971	1986	Change 1971-1986	1971	1986	Change 1971-1986	1971	1986	Change 1971-1986
	thousand hectares		percent	thousand hectares		percent	thousand hectares		percent
0-10 km zone	42	59	39.5	16	9	-45.2	63	25	-60.7
10-20 km zone	48	50	3.9	15	6	-60.6	83	21	-74.2
20-30 km zone	93	104	12.0	18	6	-64.8	132	25	-81.4
30-40 km zone	59	74	25.2	12	5	-59.0	108	29	-73.1
40-50 km zone	98	110	11.6	26	8	-70.2	160	28	-82.7
50-60 km zone	74	133	81.1	27	8	-72.3	132	44	-66.5
60-70 km zone	129	136	5.2	24	7	-69.7	185	36	-80.7
Total	**544**	**667**	**25.5**	**138**	**48**	**-63.1**	**863**	**207**	**-74.2**

Note:
10 kilometre radial buffers were used to classify data concentrically around Riding Mountain National Park.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 5: Change in Woodland Area, 1971-1986

Notes:
Woodland change refers to change in proportion of zone farmland. Municipalities making up the Riding Mountain Biosphere Reserve are outlined around the park.
Sources:
Statistics Canada, National Accounts and Environment Division and the Census of Agriculture.

taking advantage of the economies of scale that result specialized functions. Increased production often implies modifying the natural environment, so that growth can take place unimpeded by environmental factors which might otherwise slow it. An extreme example of this is the use of a green house where natural conditions are so controlled that almost any crop can be grown at any latitude. A less extreme example is the growth of a typical field crop. Environmental factors such as moisture level, flora diversity, fauna variety, soil tilth, wind strength and nutrient availability are all controlled by man. Implementing these types of controls on a large scale (millions of hectares) has inevitable consequences for the natural environment. For example, agricultural production can change the water table level and may reduce the number of animal species present by limiting vegetational diversity which are food supplies to particular wildlife species.

The agricultural activity surrounding Riding Mountain is not the intense, high yielding type found in the mid-western United States. The range of crops that can be grown economically at such northerly latitudes is small, and consists mainly of grains and cereals, or close-row type crops. Table 5 summarizes how the majority of cultivated land is being utilized.

Close-row crops dominate the study area. In total they made up more than 85% of cultivated land in 1986, a decrease from more than 90% in 1971. The remainder of cropland in the study area is planted in forage type crops such as tame hay. Crop cover around the park is important because it influences food supply for wild animals, determines soil erosion rates, affects soil quality, affects water quality and influences ecological stability by limiting species diversity. The downward trend suggested by the data, away from completely close-row monoculture is positive because it indicates that crop rotation may be increasing and that the cropping base is becoming more diverse from an ecological perspective. Two crop types of

Map 6: Farm Revenue per Hectare of Farmland, 1986

Notes:
Farm revenues refer to farm sales in 1986. Municipalities making up the Riding Mountain Biosphere Reserve are outlined around the park.
Sources:
Statistics Canada, National Accounts and Environment Division and the Census of Agriculture.

Table 5: Change in Close-Row Monoculture Cropped Area, 1971 - 1986

Radial zone	Cultivated land area			Close-row monoculture area			Close-row monoculture proportion of total cultivated land		
	1971	1986	Change 1971-1986	1971	1986	Change 1971-1986	1971	1986	Change 1971-1986
	thousand hectares		percent	thousand hectares		percent			
0-10 km zone	153	185	21.3	131	143	9.1	85.9	77.3	-10.0
10-20 km zone	203	183	-9.7	180	152	-15.8	88.9	82.8	-6.8
20-30 km zone	217	226	4.2	192	185	-3.7	88.4	81.7	-7.6
30-40 km zone	211	219	3.8	195	198	1.7	92.6	90.7	-2.1
40-50 km zone	229	244	6.4	202	203	0.6	88.3	83.4	-5.5
50-60 km zone	229	251	9.5	210	217	3.5	91.4	86.4	-5.5
60-70 km zone	257	266	3.6	231	233	0.6	90.1	87.5	-2.9
Total	**1 499**	**1 574**	**5.1**	**1 342**	**1 331**	**-0.8**	**89.5**	**84.6**	**-5.6**

Note:
Cultivated land refers to land under crops and land in summerfallow.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

note are oilseeds and specialty crops, which have both increased significantly over the study period.

The volume of agricultural fertilizers applied within 70 kilometres of Riding Mountain National Park has more than quintupled during the study period, from roughly 20 000 tonnes in 1970, to almost 150,000 tonnes in 1985. The application rate also increased from 65 kilograms per hectare to 145 kilograms per hectare. (See Table 6 and Map 7.)

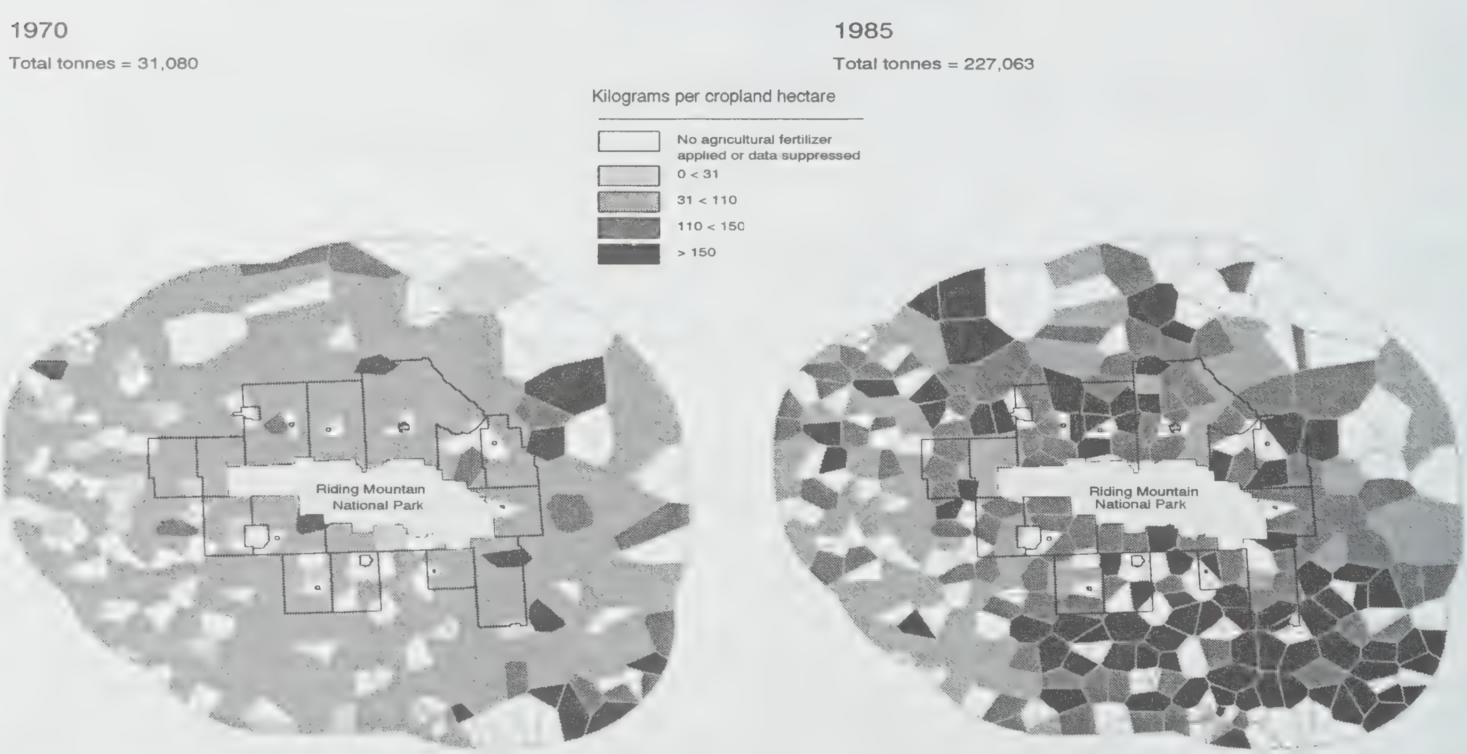
These rates have increased sharply, but are still well below those found in eastern Canada which can exceed 2 000 kilograms per hectare. Fertilized area around the park has gone up by 235% over the study period.

Table 6: Change in Commercial Agricultural Fertilizer Application, 1970 - 1985

Radial zone	Commercial fertilizer tonnage 1970	1985	Change 1970-1985	Area fertilized 1970	1985	Change 1970-1985	Application rate 1970	1985	Change 1970-1985
	tonnes		percent	thousand hectares		percent	kg per hectare		percent
0-10 km zone	1 843	14 382	680.3	28	106	279.1	66.13	136.12	105.9
10-20 km zone	2 950	16 533	460.4	43	119	175.3	68.52	139.47	103.5
20-30 km zone	2 944	23 258	689.9	47	147	215.0	62.98	157.95	150.8
30-40 km zone	2 576	22 059	756.3	43	154	257.3	59.68	143.00	139.6
40-50 km zone	2 989	22 022	636.9	46	157	237.6	64.28	140.33	118.3
50-60 km zone	3 009	25 902	760.8	48	171	255.9	62.59	151.40	141.9
60-70 km zone	3 635	25 076	589.8	53	179	236.6	68.47	140.33	104.9
Total	**19 947**	**149 233**	**648.2**	**309**	**1032**	**234.7**	**64.66**	**144.55**	**123.6**

Note:
10 kilometre radial zones were used to classify data concentrically around Riding Mountain National Park.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 7: Commercial Agricultural Fertilizer Application Rates, 1970 and 1985



Notes:
Fertilizer data for 1970 were estimated from expense data These maps represent areas within 90 km radius of the park. Municipalities making up the Riding Mountain Biosphere Reserve are outlined around the park.
Source:
Statistics Canada, National Accounts and Environment Division.

Fertilizer tonnages for 1971 were estimated from fertilizer expense data. Changing commercial fertilizer tonnages do not fully account for increases in commercial nutrients applied. Fertilizer nutrient contents have been increasing steadily over time. The average nutrient content of fertilizers in 1971 was 48%. By 1986 this value had increased to 58% (Agriculture Canada, 1987).

Agricultural pesticide applications have also increased substantially in the study period. Pesticide expenditures indicate that there has been a 744% increase in pesticides applied. These increases are large but actual application rates are one third of those in eastern regions of Canada. The use of pesticide expense data does not directly indicate changing pesticide volumes or toxicity levels. (See Tables 7 and 8, Map 8.)

Table 7: Change in Agricultural Pesticide Expenditures and Application Rates, 1970 - 1985

Radial zone	Agricultural pesticide expenditures 1970	Agricultural pesticide expenditures 1985	Agricultural pesticide expenditures Change 1970-1985	Cultivated land area 1970	Cultivated land area 1985	Cultivated land area Change 1970-1985	Value of pesticide per hectare of cultivated land 1970	Value of pesticide per hectare of cultivated land 1985	Value of pesticide per hectare of cultivated land Change 1970-1985
	constant 1985 dollars		percent	thousand hectares		percent	dollars per hectare		percent
0-10 km zone	315 053	2 966 482	841.6	153	185	21.3	2.1	16.0	676.4
10-20 km zone	480 591	3 350 309	597.1	203	183	-9.7	2.4	18.3	671.7
20-30 km zone	422 734	4 009 348	848.4	217	226	4.2	1.9	17.7	810.0
30-40 km zone	489 741	4 209 813	759.6	211	219	3.8	2.3	19.2	727.8
40-50 km zone	522 824	3 668 696	601.7	229	244	6.4	2.3	15.1	559.5
50-60 km zone	457 376	4 407 643	863.7	229	251	9.5	2.0	17.5	780.4
60-70 km zone	516 911	4 444 918	759.9	257	266	3.6	2.0	16.7	730.2
Total	**3 205 230**	**27 057 210**	**744.2**	**1499**	**1 574**	**5.1**	**2.1**	**17.2**	**703.6**

Note:
10 kilometre radial zones were used to classify data concentrically around Riding Mountain National Park.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 8: Agricultural Pesticide Application Rates, 1970 and 1985

Note:
These map represents areas within a 90 km radius of the park. Municipalities making up the Riding Mountain Biosphere Reserve are outlined around the park.
Source:
Statistics Canada, National Accounts and Environment Division.

Table 8: Change in Areas Sprayed With Insecticides and Herbicides, 1970 - 1985

Radial zone	Area sprayed for insects			Area sprayed for weeds		
	1970	1985	Change 1970-1985	1970	1985	Change 1970-1985
	hectares		percent	hectares		percent
0-10 km zone	3 316	6 124	84.7	41 538	111 147	167.6
10-20 km zone	5 234	5 043	-3.6	63 379	118 755	87.4
20-30 km zone	6 831	9 309	36.3	64 367	145 373	125.9
30-40 km zone	3 541	10 591	199.1	62 060	152 467	145.7
40-50 km zone	4 595	15 761	243.0	68 747	150 081	118.3
50-60 km zone	3 250	15 370	373.0	69 604	164 822	136.8
60-70 km zone	4 425	16 330	269.0	72 581	175 276	141.5
Total	**31 191**	**78 528**	**151.8**	**442 276**	**1 017 921**	**130.2**

Note:
10 kilometre radial zones were used to classify data concentrically around Riding Mountain National Park.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

The increase in agricultural inputs around the park does not imply that the park itself is receiving increased inputs. The transportation mechanisms bringing residual agricultural inputs into the park protect the park to some degree. Streamflow is downslope away from the park, keeping water soluble pesticides and fertilizer nutrients from entering the park in surface water. Ground water is a possible route of entry, but the extent too which this source contributes to loadings on the park is very difficult to quantify without detailed subsurface hydrology data. More probable entry routes are via the wind, and in birds and animals as they forage in fields around the park.

CONCLUSIONS

Riding Mountain National Park has long been threatened by agricultural encroachment. The natural geographic barrier posed by the escarpment has always protected the park, and despite the changes that have occurred around the park, wildlife continues to thrive.

However, agricultural activities around Riding Mountain National Park are still intensifying.

- Tilled land areas close to the park have increased by more than 20%.
- Woodland areas close to the park have declined by more than 45%.
- Pesticide use has increased markedly.
- Fertilizer application rates have more than doubled.
- Fertilized areas have more than tripled.

The land base used by agriculture is expanding to take up more and more land. At the same time, cultivation activities are also increasing with higher proportions of farmland going into production. Farm pesticide and fertilizer application rates are also increasing, placing additional stress on natural systems. Reductions in biodiversity around the park brought on by large scale agricultural development and mono-cropping are potentially dangerous to established ecological balances within the park. Wildlife food supplies and subsequent population stabilities are as a result at higher risk.

These facts lead to important questions that will have to be answered if the relationship between the park and its surroundings is to remain stable in the long term. For example, what are the effects of current agricultural practices and what will further agricultural development do? Indeed, is the current relationship sustainable? What formula can be used to weigh environmental costs against the benefits of agricultural development? What measures can be taken to ensure a long term, viable co-existence? These and other related questions will have to be carefully considered by society in the years ahead.

DATA LIMITATIONS

This type of analysis has limitations that should be described. Micro-data for the Census Enumeration Areas used in this study, are stored on a single geographic co-ordinate, otherwise known as a point. This information has to be “rolled up” or aggregated to larger areas representing large land surfaces. The accuracy of this point-polygon match is determined by the density of points per polygon and the spatial distribution of the data represented by the points. In brief, where point densities are too low results have to be suppressed or ground truthed using paper maps. (Hamilton, and Trant, 1989, p. 340) The Riding Mountain study has used large surface areas with high point densities to ensure statistical reliability. The area is

also more than 80% farmland, making the data distribution associated with the points quite homogeneous.

Other problems can arise when micro-data are aggregated to larger zones. Averaging of values can lead to under or over emphasis of certain characteristics for component smaller areas. The advantage of using composite concentric zones is that aggregate trends become discernible in contrast to the "noise" that is generated by individual data points.

REFERENCES

Agriculture Canada. *Statistics on Canadian Fertilizer Consumption 1985/1986.* Ottawa, 1987.

Dumanski. et al. "Soil Conservation in Canada." Journal of Soil and Water Conservation, Soil Conservation Society of America, July/August, 1986.

Environment Canada, *The State of Canada's Environment.* Ottawa, 1991.

Hamilton, K.E, and Trant, D.F. "Statistical Aspects of the Application of Geographic Information Systems in Canadian Environment Statistics." *Journal of Official Statistics*, Statistics Sweden, 5,1989.

Krawchuk, W.A. "The Riding Mountain Biosphere Reserve: A Synthesis of the Natural Resource Database". Masters Thesis. University of Manitoba, 1990.

Parks Canada. *Riding Mountain National Park Management Plan.* Environment Canada, Ottawa, 1987.

Tabulenas, D.T. *A Narrative Human History of Riding Mountain National Park and Area; Pre-history to 1980.* Parks Canada, micro-fiche report series 102, 1983.

6 The 1991 Census of Agriculture: Land Management for Soil Erosion Control

by Douglas Trant[1]

INTRODUCTION

Soil erosion and land degradation in general are problems of increasing economic and environmental concern. The main economic concern relating to land degradation is the loss of soil productivity, while the air and water pollution resulting from wind and water erosion are the primary environmental quality issues. Until recently, soil productivity declines have been masked by technological advances in the agricultural chemical industry, by the development of higher yielding cultivars, and by a seemingly endless supply of land and water resources. Investigation indicates that the economic costs of these degradation problems exceed one billion dollars annually, in terms of lost production (Fox and Coote, 1986). The environmental costs of water and air pollution resulting from continued wind and water erosion may be even higher. Although no estimates are available for Canada, estimates based on an American cropland area four times that of Canada's indicate that the combined annual environmental and economic costs of the U.S. soil erosion problem range from 4 to 44 billion dollars (Steiner, 1990). The magnitude of this range demonstrates just how difficult it is to estimate the cost of soil erosion.

A new land management module was added to the 1991 Census of Agriculture to provide a first comprehensive look at soil conservation practices on farms in Canada. Farm operators were asked to respond to a series of questions, mostly with simple yes or no answers. Because the survey is new, some of the results must be interpreted cautiously. Nonetheless, these data provide an indication of how well soil erosion and land degradation are being addressed across Canada. This chapter summarizes soil erosion control practices on a provincial basis.

1. The author would like to thank Marcia Santiago for her contribution to the research which supports this chapter. Thanks should also go to scientists at Agriculture Canada's Centre for Land and Biological Resources Research who provided valuable comments.

SOIL EROSION CONTROL PRACTICES

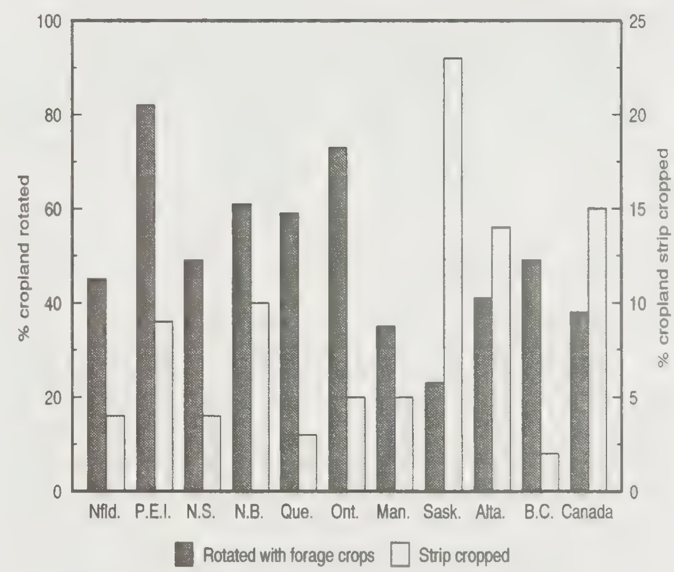
Soil erosion control practices on farms in Canada are shown in Table 1. More than a third of farms in Canada (36.9%) used a forage based crop rotation system on some of their cropland. This type of crop rotation helps promote soil aggregate stability and improves soil structure while recharging soil nitrogen when legumes such as alfalfa or clover are used. The historical decline in forage based crop rotations has contributed to soil quality deterioration in Canada (Dumanski et al.,1986).Crop rotations with forage are more prevalent in Eastern Canada. Differences in farm types account for much of the regional variation.

Table 1: Farms Reporting Erosion Control, 1991

Erosion control	Number of farms	Percent of farms
Crop rotation using forage	103 355	36.9
Winter cover crop	24 289	8.7
Grassed waterway	31 474	11.2
Strip cropping	22 006	7.9
Contour Cultivation	25 630	9.2
Other practices	61 818	22.1

Note:
A farm may use more than one erosion control practice, or none at all.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 1: Potential Cropland Area in Forage Rotations and Strip Cropping, 1991

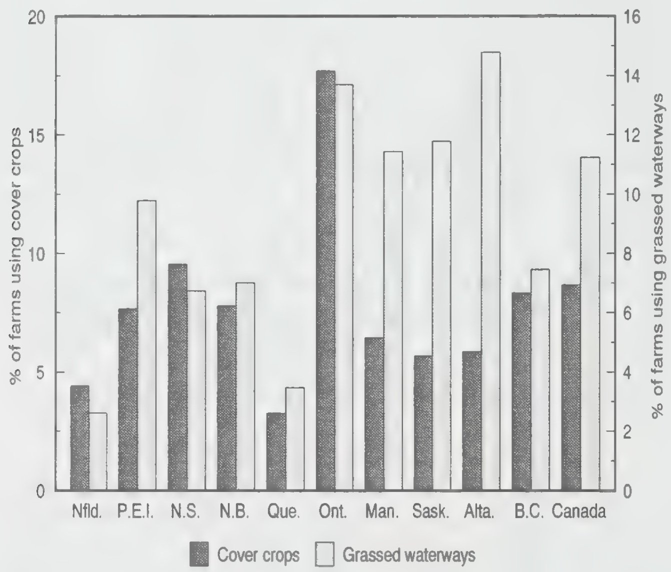


Note:
Not all cropland area on reporting farms is protected by a particular erosion control practice.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Strip cropping is an erosion control method where crops are planted in strips, and are often laid out parallel to the slope contour. For example, a grain crop can be planted along the contour, with alternating strips of hay and grain. The hay crop checks water run-off from the grain crop. Wind erosion can also be prevented using strip cropping. One crop can protect the other from high wind during a particularly vulnerable growth or harvest stage. Table 1 and Figure 1 show that strip cropping is used on 7.9% of farms managing 14.8% of cropland in Canada. It is most prevalent in Western Canada.

Winter cover crops are used on 8.7% of farms managing 10.5% of cropland. This practice serves mainly as protection against wind erosion in winter months. However, winter cover crops can also provide protection in spring when intense rainfall might erode unprotected soil surfaces (Figure 2).

Figure 2: Number of Farms Using Winter Cover Crops and Grassed Waterways, 1991



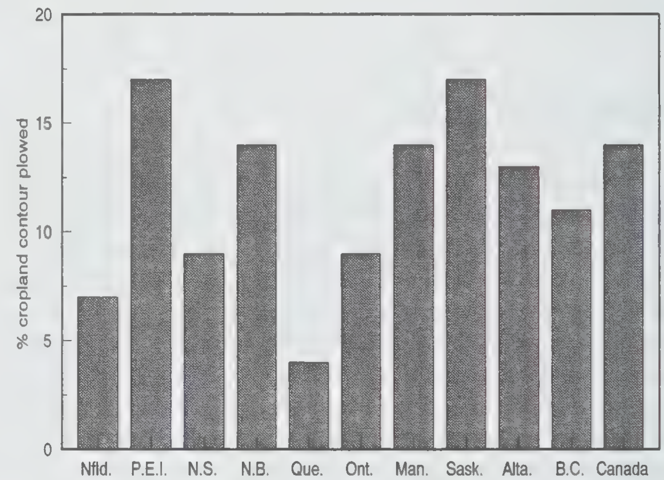
Note:
There are indications that the area of winter cover crops has been over reported by farmers responding to the Census.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Grassed waterways are an erosion control measure used to check overland flow and prevent gully erosion. Exposed soil surfaces on slopes can form gullies that may eventually grow in size to form ditches or ravines. Grassed waterways direct overland flow and protect soil surfaces.

Nationally, 11% of farms reported using grassed waterways. Alberta farms reported using this practice more than in any other province.

Another method of erosion control is to cultivate the soil parallel to the contour of the slope. This method traps soil particles between plough furrows rather than allowing water and soil particles to gain velocity and move down slope. Across the country 9% of farms use this method and as much as 14% of cropland is protected by these measures. Figure 3 shows the proportions of cropland potentially protected by contour cultivation. Saskatchewan and Prince Edward Island top the list with over 16% of their cropland potentially protected by contour cultivation.

Figure 3: Cropland Potentially Protected by Contour Cultivation, 1991



Note:
The percentages above represent a maximum and tend to overestimate area under contour cultivation.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2 looks at farms by erosion control category, by province. Ontario farmers are more likely to use multiple soil erosion control practices. Seven percent of Ontario farmers used 4 or more erosion control practices.

Newfoundland has the smallest proportion of farmers using erosion control (Figure 4). This is due primarily to the types of agriculture found in Newfoundland. In 1991, Newfoundland had only slightly more than 2 000 hectares that were prepared for seeding. In contrast, Saskatchewan has single farms with seeded areas larger than 2 000 hectares. British Columbia and Nova Scotia have the second and third lowest percentages of participants in erosion control respectively. Both provinces have large tree fruit areas which contribute to their total cropland areas, and as such do not normally require tillage or substantial erosion control. The province with the highest percentage is Saskatchewan where almost 72% of all farmers use some form of erosion control. Sixty three percent of farms in Canada report employing one or more erosion control practices (Figure 4).

Table 2: Number of Farms Employing Erosion Control, 1991

Number of erosion control practices	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Canada
No erosion control	485	710	2 401	1 801	18 769	21 913	8 742	17 300	18 025	12 410	**102 556**
1 erosion control	160	1 063	1 059	978	15 959	25 237	8 947	24 160	22 226	4 846	**104 635**
2 erosion controls	44	260	317	267	1 961	10 474	4 064	9 745	8 992	1 237	**37 361**
3 erosion controls	29	209	126	110	892	6 255	2 610	6 134	5 343	492	**22 200**
4 erosion controls	6	68	44	63	268	3 065	922	2 396	1 868	147	**8 847**
5 erosion controls	1	34	24	25	126	1 256	305	823	616	57	**3 267**
6 erosion controls	0	14	4	7	96	345	92	225	136	33	**952**
7 erosion controls	0	3	5	1	5	88	24	57	39	3	**225**
All farms	**725**	**2 361**	**3 980**	**3 252**	**38 076**	**68 633**	**25 706**	**60 840**	**57 245**	**19 225**	**280 043**

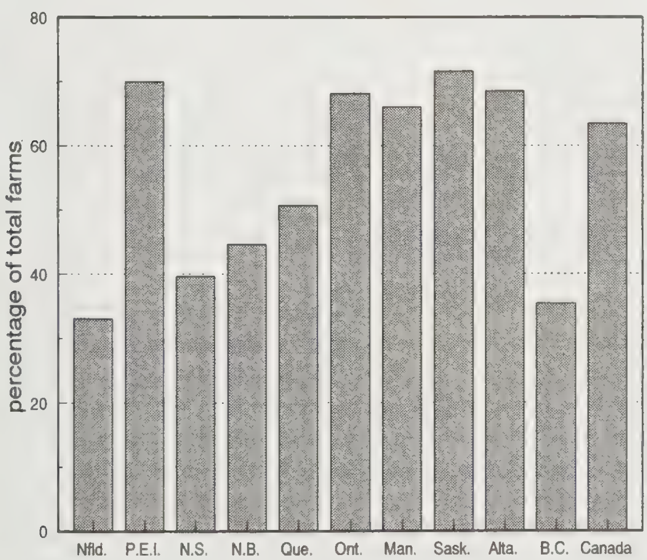
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 3: Erosion Control Practice by Farm Type, 1991

Farm type	Crop rotation	Cover crops	Grassed waterways	Strip cropping	Contour cultivation	Other practices
	percentage of farms					
Livestock operations	43.4	10.0	12.7	7.2	9.9	21.3
Wide-row cropping [1]	65.5	20.1	12.9	7.6	8.7	27.3
Close-row cropping [2]	41.6	11.8	11.4	3.9	12.5	28.6
Forage cropping	57.6	8.0	11.9	3.4	6.4	19.7
Specialty farming and other	27.3	8.7	8.0	5.8	8.3	20.6

Notes:
Generalized farm types are derived by aggregating farm types from the Census of Agriculture. Ideally a land-based farm typing should be used here where farms are grouped according to land use rather than on sales. Agriculture Canada is proposing to analyse erosion control using land based farm types in the near future.
[1] Corn, soybeans, vegetables and other crops typically grown in wide rows more than 10 cm.
[2] Wheat, oats, barley and other crops typically grown in narrow rows less than 5 cm apart.
Sources: Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 4: Farms Using One or More Erosion Control, 1991



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 3 shows the association between farm type and erosion control practice. Wide-row crops are potentially the most erosive crop type (Wischmeier, 1978). The data indicate that wide-row croppers do in fact respond to higher erosion risk and are the most frequent users of erosion control in 4 out of 6 erosion control techniques. Close-row cropping, potentially the second most erosive farm type, employs more contour cultivation and "other" erosion control practices most frequently.

SEED BED PREPARATION AND SOIL EROSION CONTROL

The 1991 Census of Agriculture asked farmers questions about their seed bed preparation techniques. Three broad practices were identified: conventional tillage, conservation tillage and no tillage. Conventional tillage actually turns soil over and buries crop residues, making the risk of soil erosion greater than with conservation tillage or no tillage. Conventional tillage methods are quite different from region to region. For example, equipment types vary, reasons for tillage vary, and the timing between tillages is often different. In conservation tillage, as the name implies,

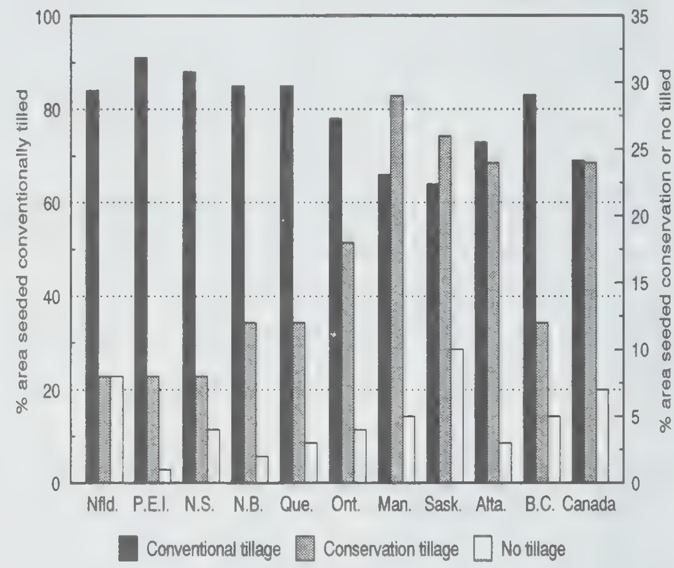
fields are cultivated fewer times with implements that do not turn the soil over. This conserves beneficial crop residues on the surface. Finally, seed bed preparation may be done without any tillage. This is considered the most environmentally benign tillage method from a physical degradation standpoint[1] (Wischmeier, 1978).

Most soil types suffer some degradation when tilled continually. Soil organic matter levels have a tendency to decline due to the increased oxidation caused by the turning and mixing action of cultivation. When organic matter levels decline most soils begin to deteriorate structurally. If a soil undergoes structural degradation and loses porosity and permeability, rain water does not infiltrate as quickly and water begins to run off. If this situation occurs on vulnerable soils, erosion becomes a definite risk. Another problem more commonly associated with conventional tillage is soil compaction. Compaction can lead to crop rooting problems by limiting the rooting zone and can also lead to water puddling in fields, which prevents cultivation until much later in the spring. One way of combating structural decline is to use a forage or legume in the crop rotation.

Seed bed preparation methods by province are shown in Figure 5. Conventional tillage is most prevalent in Prince Edward Island with more than 90% of seeded area cultivated with this method. Conservation tillage is most common in Manitoba at close to 30% of area prepared for seeding. No-tillage is also highest in the Prairies with a value approaching 10% in Saskatchewan.

Table 4 describes the association between soil erosion control and seed bed preparation. This table provides an indication of the degree to which agricultural soils are being protected across Canada. Nationally, more than 29 million hectares were prepared for seeding in 1991 with conventional, conservation tillage or no tillage. Four and one half million hectares out of 29 million (15.3%) had no erosion control applied and were not tilled using a conservation technique. Although not all require erosion control, these soils are potentially under the greatest stress, and could benefit the most from improved tillage practice or through the use of some erosion controls. Conversely, this implies that 24.5 million hectares (84.7%) of the area prepared for seeding had at least one erosion control applied, or was cultivated using methods that do not promote soil erosion. This is a positive sign and indicates that Canadian farmers are indeed combating the erosion problem.

Figure 5: Seed Bed Preparation Methods, 1991



Note:
No till areas indicated are higher than actual due to respondent error.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 4: Seed Bed Preparation Methods and Erosion Control Practices, 1991

Number of erosion control practices	Conventional tillage	Conservation tillage	No tillage	Total seeded area
	thousand of hectares			
No erosion control	4 447	1 110	356	**5 913**
1 erosion control	8 014	2 592	773	**11 379**
2 erosion controls	3 705	1 582	407	**5 694**
3 erosion controls	2 302	1 026	234	**3 562**
4 erosion controls	1 038	519	116	**1 673**
5 erosion controls	364	196	48	**608**
6 erosion controls	95	49	12	**156**
7 erosion controls	21	17	6	**44**
Total seeded area	**19 986**	**7 091**	**1 952**	**29 029**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

CONCLUSIONS

The 1991 Census of Agriculture provides important baseline information on agricultural soil conservation practices in Canada. Data for a single year provide only a snapshot of soil conservation practices and obviously give no indication of whether the situation is getting better or worse. Nationally, the indications are generally encouraging, insofar as farm operators with 84.7% of seeded area use some form of soil erosion control or conservation practice, and that farms with the most potentially erosive crops are the most frequent users of 4 out of 6 erosion control measures.

1. The 1991 Census responses to the "no-tillage" question are somewhat overestimated because in some instances hay crops were reported as "no till" when only crops requiring seed bed preparation should have been reported.

The real question is: are farmers winning the fight? To answer this question more information is needed. For example, where is the 4.4 million hectares of conventionally tilled land to which no erosion control is applied? Is it located on vulnerable soils? Is the area steeply sloped? Do the farms generate significant net revenues or are they among the less productive? Future research should provide insight into these questions as Agriculture Canada's soil landscape maps are more directly linked to the Census data base. This will allow detailed analysis of erosion risk as it relates to farm land use, farm economics and agricultural conservation practices.

REFERENCES

Dumanski, J., D.R. Coote, G.Luciuk, C.Lok,"Soil Conservation in Canada", *Journal of Soil and Water Conservation*. 41:4, July-August 1986.

Fox, M.G. and Coote D.R., *A Preliminary Economic Assessment of Agricultural Land Degradation in Atlantic and Central Canada and Southern British Columbia*. Development Consulting House (DCH) For Agriculture Canada, Contribution 85-70, Ottawa, 1986.

Steiner F.K., Soil Conservation in the United States. Johns Hopkins University Press, Baltimore, 1990.

Trant, D., *Estimating Agricultural Soil Erosion Losses from Census of Agriculture Crop Coverage Data*, Research Paper Series #27, Analytical Studies Branch, Statistics Canada, 1989.

Wischmeier, W.H. and D.D. Smith, *Predicting Rainfall Erosion Losses - A Guide to Conservation Planning*. Agricultural Handook #537, Washington, D.C., United States Department of Agriculture, 1978.

7 Household Activity, Household Expenditures and the Environment

by Marcia Santiago

INTRODUCTION

Many areas of daily household activity affect the natural environment. Some, such as the consumption of fossil fuels for residential heating or automobile operation, have direct impact in terms of using natural resources and in releasing pollutants. There are also other activities that are relevant to environmental quality but whose impact is indirect. One example is the use of recycling facilities, as an alternative to the immediate disposal of solid waste.

Using data from two Statistics Canada surveys, one on household behaviour (Household Environment Survey, 1991) and another on household expenditures (Family Expenditure Survey, 1990, abbreviated as FAMEX), this chapter describes patterns of household activity and household expenditure that are relevant to environmental concerns. The reader should bear in mind that the data presented in this chapter describe the reported activity of households, which may be different from their actual activity. In the case of environmentally relevant behaviour, this effect has been labelled a "green bias". It has been shown that a heightened media or social profile may influence respondents to give what they expect to be 'appropriate' answers (Rathje 1990). The reader must also recognize that expenditure and activity decisions are conditioned as much by social and economic considerations as they are by conscious response to an environmental imperative. Nevertheless, expenditures and activity do provide some important insight into the relationship of households and the environment.

Three general areas are discussed: access to and use of recycling facilities, energy and water consumption, and commuting patterns. Patterns of activity and expenditure are summarized, along with their relationship to a number of geographic and economic factors.

ACCESS TO AND USE OF RECYCLING SERVICES

Although the public has long been concerned about the disposal of solid waste, this issue has become much more prominent in recent years. Perhaps in response to this issue, there has been widespread implementation of recycling facilities and programs. In 1991, access to various recycling facilities was reported by almost half of the households questioned in the Household Environment Survey. Access to paper recycling facilities was reported by 53% of households, with 49%, 50% and 42% of households reporting access to metal can, glass and plastic recycling facilities respectively. Among households that reported access to these facilities, about 86% reported that they used them.

Table 1 shows the rates of access to and use of paper recycling facilities in fifteen Census Metropolitan Areas. There is quite a range in the reported access to this service. The highest rates of access are reported in Kitchener-Waterloo (94%) and Victoria (92%), while Québec (24%) and Montréal (37%) report the lowest proportions of households with access. Reported use of the facilities also varies considerably, with the lowest rate reported in Winnipeg (55%) and the highest rate in Toronto (98%)

Table 1: Access to and Use of Facilities for Paper Recycling by Census Metropolitan Area, 1991

	With access		Reporting use	
	percent of households			
Halifax	47	E	84	E
Québec	24	F	79	F
Montréal	37	E	77	E
Ottawa	70	D	91	D
Toronto	74	C	98	C
Hamilton	81	D	94	D
St. Catharines-Niagara	85	C	94	D
Kitchener-Waterloo	94	E	94	D
London	66	E	94	E
Windsor	77	D	95	D
Winnipeg	78	E	55	E
Edmonton	68	D	89	D
Calgary	47	D	75	E
Vancouver	72	D	93	D
Victoria	92	D	92	D
Canada	**53**	**B**	**86**	**B**

Note:
See the standard error symbols at the end of this chapter.
Source:
Statistics Canada, Household Environment Survey.

The type of service to which a household has access is related to the size of the municipality and to the type of dwelling (Table 2). This is in part because larger municipalities were the first to implement curbside collection programs and these generally served only single detached dwellings. Thus, it follows that the highest access rate (76%) is reported by households in single detached dwellings in major metropolitan areas. The same group also reports the highest rate of use (91%). In contrast, access

rates for apartment dwellers are quite low (23% to 36%). Access might well be more difficult for apartment dwellers, which would partially explain their lower usage rate.

Table 2: Access to and Use of Facilities for Paper Recycling by Area and Dwelling Type, 1991

	With access	Reporting use
	percent of households	
Major metropolitan areas (population of 100 000 and over)		
Single, detached	76	91
Single, attached	66	90
Apartment or flat	35	83
Other	56	92
Mid-size metropolitan areas (population between 30 000 and 99 999)		
Single, detached	64	87
Single, attached	55	82
Apartment or flat	36	69
Other	52	81
Other urban areas (population less than 30 000)		
Single, detached	52	50
Single, attached	46	79
Apartment or flat	36	71
Other	43	63
Rural areas		
Single, detached	34	76
Single, attached	30	80
Apartment or flat	23	72
Other	26	65
Canada	**53**	**86**

Source:
Statistics Canada, Household Environment Survey.

ENERGY AND WATER CONSUMPTION

It is reasonable to say that many households have considerable scope to reduce their consumption of water and energy. While concern for the environment may be a factor in the decision to do so, the potential to reduce utility bills is likely to be an important motivator as well.

In 1990, urban households spent, on average, $1 170 on the consumption of water, fuel and electricity, which represents 14% of their spending on shelter, or 2.4% of their total spending. The average cost of water supply to primary residences was $118, or 10% of household spending on fuel and energy.

At least partly in response to these costs, many households have adopted energy-saving habits. Seventy-one percent of households with a thermostat report either that it is programmable or that it is regularly lowered during the heating season (Table 3).

Table 3: Energy and Water Consumption Practices and Expenditures

Percentage of households in 1991	
With a thermostat	88
With a programmable thermostat	13
With a regularly lowered thermostat	58
With compact fluorescent bulbs	11
With low-flow shower heads	28
With low-flow toilet tanks	9
Average household expenditure in 1990 (dollars per year)	
Electricity	644
Heating fuel	408
Water supply	118

Sources:
Statistics Canada, Household Environment Survey and Family Expenditure Survey.

Water-conserving practices are not as widely adopted as those for energy. Comparatively few households have either low-flow shower heads (28%) or low-flow toilet tanks (9%). This may be because, in many cases, the cost of water supply is not directly related to the quantity used.

The tenure of a dwelling influences the degree to which the household feels responsible for the dwelling's condition and, therefore, its energy and water consumption. Households owning their place of residence have control over changing fixtures (like the thermostats), whereas tenants usually depend on their landlords to make these types of changes. This factor may contribute to the differences in energy- and water-use habits between households owning their dwellings and those renting. (Table 4). A higher proportion of homeowners report implementing conservation measures.

Table 4: Energy and Water Consumption Practices by Tenure of Dwelling, 1991

	Owned dwellings	Rented dwellings
	percent of households	
With compact fluorescent bulbs	14	6
With thermostats	87	76
With programmable thermostats	16	7
With regularly lowered thermostat settings	56	42
With low-flow shower heads	34	19
With low-flow toilet tanks	12	5
All households	**64**	**36**

Source:
Statistics Canada, Household Environment Survey.

TRANSPORTATION

Commuting to the place of work is a common feature of most households' transportation activity, although the needs of households vary considerably. The potential environmental impact from this activity also varies depending

on the modes of transport that are chosen: walking or cycling instead of using a motor vehicle, taking public transportation rather than driving a private vehicle.

The cost of transportation accounted for 17%, or $5 603, of total household expenditure (FAMEX, 1990). Most of this amount (88%) is for private vehicles, the rest being for public transport. Fuel alone accounts for 23% of expenditures on private vehicles.

Households show a clear preference for private automobile travel when commuting to and from work. Overall, 76% of households reported at least one member who drives to work (Table 5). This rate does vary among metropolitan areas, although it is generally quite high (Table 6). The rate of private vehicle use ranged from 83% in Windsor and Kitchener-Waterloo, to 65% in Halifax.

Table 5: Commuting Patterns by Area and Dwelling Type, 1991

	Households where at least one member		
	Has employment outside the home	Drives private vehicle	Uses public transportation
	thousand	percent	
Major metropolitan areas (population of 100 000 and over)			
Single, detached	2 255	77	17
Single, attached	639	74	24
Apartment or flat	1 391	57	34
Other	42	...	...
Other areas			
Single, detached	1 859	82	2
Single, attached	203	77	5
Apartment or flat	254	67	9
Other	115	...	...
Canada	**6 758**	**76**	**15**

Source:
Statistics Canada, Household Environment Survey.

In contrast, only 15% of Canadian households report that at least one member uses public transportation for travelling to and from their workplace. This rate also varies through metropolitan areas. It is generally higher in the larger and more densely populated metropolitan areas such as Toronto (33%) and Montréal (30%).

INCOME AND HOUSEHOLD ACTIVITY

Environmentally relevant expenditures and activities may also be associated with household income. This variable is correlated with some of the geographic factors, such as urban structure, already discussed in this chapter. Income is related to the level of education attained, which might in turn influence the overall environmental awareness and activities chosen in a household.

Table 6: Commuting Patterns by Census Metropolitan Area, 1991

	Households where at least one member				
	Has employment outside the home	Commutes by private vehicle as the driver		Commutes by public transportation	
	thousands	percent			
Halifax	85	65	D	16	F
Québec	174	78	D	17	F
Montréal	846	68	D	30	E
Ottawa	193	67	D	27	E
Toronto	952	69	D	33	E
Hamilton	161	80	D	11	G
St. Catharines-Niagara	81	84	D	6	G
Kitchener-Waterloo	87	83	D	...	H
London	91	80	E	16	F
Windsor	64	83	D	6	G
Winnipeg	163	74	D	21	E
Calgary	207	77	D	17	F
Edmonton	208	80	D	16	F
Vancouver	456	80	D	18	E
Victoria	68	69	E	13	G
Canada	**6 759**	**76**	**B**	**15**	**D**

Note:
See the standard error symbols at the end of this chapter.
Source:
Statistics Canada, Household Environment Survey.

In fact, higher household incomes are associated with higher rates of adoption of certain environmentally useful practices (Table 7). With respect to energy conservation practices, households in the highest income group report the highest use of compact fluorescent bulbs (16%); the proportion of households with programmable or regularly lowered thermostats is also highest in this group (79%). For access to facilities for paper recycling, the rates range from 40% in the lowest income group to 73% in the highest income group. The reported rate of use varies in much the same way, ranging from 77% to 93%. In both cases, the differences are also related to factors discussed in previous sections: tenure and type of dwelling. Higher income households are more likely to be owners and reside in single detached dwellings than households in lower income groups.

In contrast to the positive correlation between income and the adoption of environmentally useful practices, Tables 8 and 9 show that the use of public transport declines in favour of automobile use as income increases.

Vehicle operation expenditures illustrate the differences in consumption between higher and lower income households (Table 8). Among households in the highest income decile, 94% are automobile or truck owners, compared to 90% in the fifth and 68% in the third deciles of income. The pattern of expenditure on automotive fuel is similar. The average expenditure increases with household

income, ranging from $659 in the first income decile to $ 2 048 in the tenth. In addition, among the higher income groups, more households report expenditures on this commodity. In contrast, the proportion of households that report expenditure on public transit is higher in the lowest two deciles of income than in the highest two. However, the opposite is true for their average expenditure on this service (Table 8). The highest proportion of households with at least one member commuting to work by public transportation is in the first income group (37%) but the lowest rate is in a middle income group, the seventh, at 21% (Table 9)[1].

Table 7: Selected Practices and Characteristics by Household Income Group, 1991

Income groups	Owning their dwelling	Thermostats programmable or lowered	Compact fluorescent bulbs	Living in single detached dwelling	Access to paper recycling facilities and reporting use
	percent of households				
First (lowest)	21	61	7	16	77
Second	23	64	6	16	86
Third	27	63	7	22	81
Fourth	37	70	6	28	88
Fifth	42	70	8	30	87
Sixth	46	72	12	35	88
Seventh	53	73	11	39	86
Eighth	65	70	12	50	89
Ninth	73	76	13	62	90
Tenth (highest)	87	79	16	74	93
Canada	**55**	**72**	**11**	**44**	**85**

Sources:
Statistics Canada, Household Environment Survey and Survey of Consumer Finance.

CONCLUSIONS

Response to recycling programs appears to be very positive. In areas where the facilities are available, most households report that they are used. Some households, those residing in less densely populated areas or those living in apartments, for instance, have lower overall rates of access.

The data suggest that households are both conscious of their consumption of water and energy, and willing to take steps towards conservation. The extent to which energy and water-efficient fixtures are used is related to income level (at least, in the case of energy) and the tenure of the dwelling.

1. Note that in contrast to Table 8 which is in income deciles, Tables 7 and 9 show income groups. Consequently, there is not an even number of households in each group, a fact that, while unimportant for this analysis, does make it impossible to compare the three tables in detail.

Table 8: Selected Transportation Expenditures, by Household Income Decile, 1991

Income deciles	Households that own vehicles	Average household expenditure			
		Automotive fuel		Public transit	
	percent	dollars	percent reporting	dollars	percent reporting
First (lowest)	21	659	22	243	84
Second	52	764	53	347	81
Third	68	952	73	383	77
Fourth	81	1 058	83	350	70
Fifth	90	1 246	92	371	70
Sixth	90	1 415	91	339	74
Seventh	94	1 436	94	396	76
Eighth	96	1 852	97	383	72
Ninth	97	1 776	96	436	74
Tenth (highest)	94	2 048	98	459	77
FAMEX cities	**78**	**1 430**	**80**	**363**	**76**

Note:
"Average household expenditure" is the mean expenditure among all families reporting a non-zero expenditure in a given category.
Source:
Statistics Canada, Family Expenditure Survey.

Table 9: Commuting Patterns by Household Income Group, 1991

Income groups	Households where at least one member		
	Has employment outside the home	Commutes by private vehicle as the driver	Commutes by public transportation
	thousands	percent	
First (lowest)	150	48	37
Second	205	50	23
Third	277	50	33
Fourth	411	56	29
Fifth	435	58	28
Sixth	504	67	24
Seventh	1 016	71	21
Eighth	1 007	77	25
Ninth	1 131	80	24
Tenth (highest)	1 622	81	23
Canada	**6 759**	**72**	**25**

Source:
Statistics Canada, Household Environment Survey.

However, Canadian households generally remain committed to the use of private vehicles. For travelling to work, commuters far prefer to drive their cars instead of using public transportation. This preference is probably related to the level of service in the transit system and the particular circumstances of individuals. The above results show, nevertheless, that those considerations are more important to the households than the possible environmental effects.

DATA SOURCES

Refer to the publication *Households and the Environment* for details on the methodology of the 1991 Household Environment Survey. For comparisons between income categories, a subset of the Household Environment Survey was selected corresponding to the urban areas that were sampled in the 1990 Family Expenditure Survey. "FAMEX cities" include St. John's, Charlottetown, Summerside, Halifax, Saint John, Québec, Montréal, Ottawa, Toronto, Thunder Bay, Winnipeg, Regina, Saskatoon, Calgary, Edmonton, Vancouver and Victoria.

Expenditure data are taken from the Family Expenditure Survey. These are based on a survey of households in Census Metropolitan Areas.

REFERENCES

Rathje, W.L. "The History of Garbage". *Garbage: The Practical Journal for the Environment* 2(4): 33-39,1990.

Statistics Canada. *Family Expenditure Survey, 1990.* Catalogue 62-555, Irregular,Ottawa, 1991.

Statistics Canada. *Households and the Environment 1991.* Catalogue 11-526, Occasional,Ottawa,1992.

Alphabetic Designation of Percent Standard Error

A	0 to.5
B	.6 to 1.0
C	1.1 to 2.5
D	2.6 to 5.0
E	5.1 to 10.0
F	10.1 to 16.5
G	6.6 to 25.0
H	25.1 +

8 Pollution Abatement and Control Expenditures

by Craig Gaston

Pollution abatement and control expenditures (PAC) are of interest as a measure of the impact of environmental regulations on affected industries and, more broadly, as part of overall environmental expenditures in national income. Since both the desirable and undesirable outputs derive from the same process, the generation of pollution can be viewed as a joint product problem. In many cases, expenditures to reduce pollution are often not distinguishable from those outlays made to improve overall performance. There are, however, some expenditures which are solely for the purpose of pollution abatement and control. These are often described as "end-of-pipe" solutions. Using this restrictive but unambiguous definition, PAC capital expenditures amounted to over $1 billion in 1989, or about 1% of total capital expenditures in Canada. Table 1 shows that the distribution of PAC expenditure is very uneven across industrial sectors.

Table 1: Relative Importance of PAC Expenditures, Selected Industries, 1989

Industrial sector	PAC operating	PAC capital[1]	Total capital	PAC/ total capital
	million dollars			percent
Manufacturing	469	918	18 942	4.3
Paper & allied	76	368	5 501	6.7
Primary metals	258	288	2 341	12.3
Petroleum & coal	36	71	961	7.4
Chemicals	44	71	1 627	4.4
Mining	77	80	7 373	1.1
Utilities	x	106	19 486	1.1
Total economy[2]	**729**	**1 188**	**89 722**	**1.3**

Notes:
[1] See Statistics Canada (1992) for more detail on this survey, especially Appendix F for an explanation of the difference between the above data and those contained in Table 2 of Statistics Canada (1992).
[2] The total excludes capital items charged to operating expenditures and capital expenditures made by residential construction, agriculture, fishing and construction industries.
Source:
Statistics Canada, Investment and Capital Stock Division.

The Pollution Abatement and Control survey, conducted for the first time in 1989 by Statistics Canada, intentionally avoided the ambiguity inherent in the use of a broader definition such as "environmental expenditures". Internationally, there is no consistent approach. A similar survey conducted in the United States asks specifically for change-in-process expenditures as well as end-of-pipe expenditures as do France, Sweden and the Netherlands. Norway has abandoned PAC surveys altogether, rather than present partial results.

There is no doubt that the Statistics Canada PAC survey represents a lower bound on environmental expenditures. A survey of environmentally related expenditures prepared for Environment Canada by Dun and Bradstreet (1991), reported $20.9 billion in capital plus operating costs in 1989, over 12 times greater than the combined capital and operating expenditures figure resulting from the Statistics Canada survey. This wide difference is not surprising since it is possible to argue that major improvements costing many millions of dollars are at least partially environmentally motivated, even though the decision to invest is dependent on a number of factors aside from environmental protection.

HISTORICAL PAC EXPENDITURES

Statistics Canada has asked respondents to its regular annual Capital Repair and Expenditure Survey (CRES) to report capital expenditures by purpose, one of which is pollution abatement and control. The respondents are asked to assign their capital expenditures to the most relevant category in recognition of the fact that many expenditures could be assigned to more than one category. Even though the total for 1989 is similar to that reported in the PAC survey of the same year, an examination of the results by establishment shows important inconsistencies, a fact which demonstrates the need for strict definitions. Nevertheless, CRES provides us with a unique source of information covering the period 1985-1990.

Table 2: Capital Expenditure by Purpose, 1985-1990

Investment categories	1985	1986	1987	1988	1989	1990
	percent of total investment					
Expansion/ modernization/other	97.4	97.7	97.7	97.6	97.1	96.8
Pollution abatement and control	**.7**	**.7**	**.6**	**1.1**	**1.7**	**2.1**
Improvement to working environment	.9	1.0	1.1	.9	.8	.7
Reduction of energy costs	.9	.7	.5	.4	.4	.4

Source:
Statistics Canada, Investment and Capital Stock Division.

Table 2 shows a marked increase in the percentage of investment in pollution abatement equipment from 1988 to 1990 largely owing to the paper and allied industries and primary metal industries.

PAC EXPENDITURES BY PROVINCE

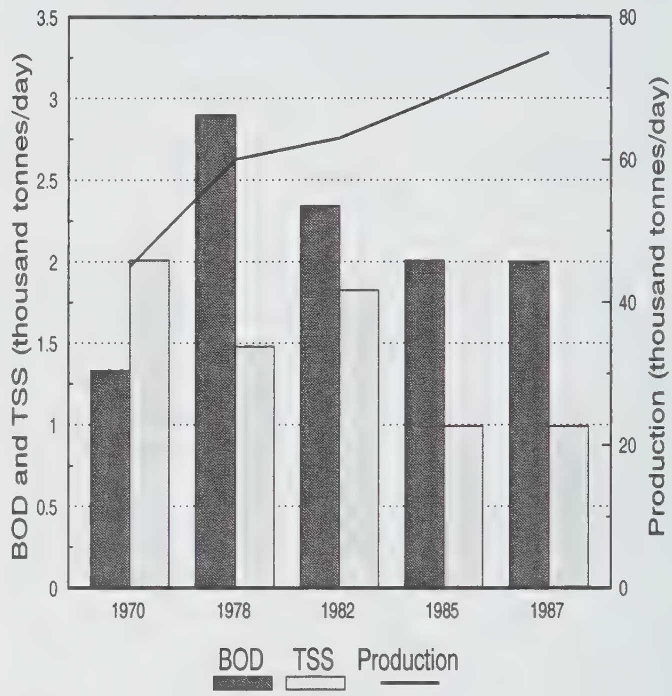
Table 3 shows that the large relative increase in PAC expenditures between 1988 and 1990 is accounted for mainly by Ontario and British Columbia. Investment in general, and investment in PAC in particular, tends to be volatile, and one would expect considerable variation of these ratios as the aggregates observed become smaller.

Although the 1989 PAC survey is felt to be more meaningful than CRES due to the stricter definitions, it is interesting to observe the movement of the latter over time (since the PAC survey itself has been conducted for only one year, 1991). Table 3 shows that no one province devotes a consistently higher proportion of investment to pollution abatement than the others.

PHYSICAL MEASURES OF POLLUTION ABATEMENT

An important measure of effectiveness of PAC expenditures is the reduction in pollutants. The 1989 PAC survey attempted to obtain information on the physical quantity of pollutants abated but experience has shown that this is difficult to achieve with a single questionnaire designed to cover all industrial sectors. Since a number of the most polluting industries are covered by environmental regulations, administrative data collected for this purpose are probably a better source of information on volumes of pollutants.

Figure 1: Discharges from Canadian Pulp and Paper Mills, 1970-1987



Source:
Environment Canada, 1991, p. 14-19.

As an example, the above chart shows the decline of pollutants from the pulp and paper industry compared with increasing production. Of course, the total volume of pollut-

Table 3: Provincial PAC Expenditures

Province	1989 PAC Survey			Capital and Repair Expenditure Survey PAC/total capital expenditure		
	PAC	Capital expenditures[1]	PAC / capital	1988	1989	1990
	million dollars		percent	percent		
Newfoundland	1.3	1 355	.1	.7	.6	1.8
Prince Edward Island	x	237	x	0	0	3.7
Nova Scotia	16.1	2 469	.7	.8	.7	.4
New Brunswick	67.3	2 010	3.3	2.6	1.0	.8
Quebec	255.4	19 512	1.3	1.5	2.5	1.4
Ontario	434.7	35 755	1.2	.8	1.5	2.0
Manitoba	12.9	2 548	.5	.3	2.4	.6
Saskatchewan	x	2 820	x	.5	.5	2.0
Alberta	182.2	11 702	1.6	.7	1.3	.7
British Columbia	200.2	10 310	1.9	2.0	1.7	5.4
Yukon	-	145	-	0	1.1	4.4
N.W.T.	x	860	x	x	x	x
Total	**1 188.0**	**89 722**	**1.3**	**1.1**	**1.7**	**2.1**

Note:
[1] The total excludes capital items charged to operating expenditures and capital expenditures made by residential construction, agriculture, fishing and construction industries.
Source:
Statistics Canada, Investment and Capital Stock Division.

ants abated is, in itself, an inadequate measure of environmental impact since the toxicity of the pollutant is also important. Recent regulations governing the production of dioxins and furans, for example, require that the levels of these chemicals be kept below the measurable concentration which, in this case, is 50 parts per quadrillion (10^{15}).

CANADIAN VERSUS UNITED STATES PAC EXPENDITURES

Unlike the Canadian survey, the U.S. industrial PAC survey asks respondents to report the portion of change-in-process investment which is related to pollution abatement. This is a subjective judgement by respondents that limits comparability both within and between sectors. The U.S. expenditures are higher than those for Canada at least partly for this reason.

Table 4: PAC Capital Expenditures as a Percentage of Total Capital Expenditures, Canada and U.S., 1989

	Total	Air	Water	Solid waste
	percent			
Canada	1.3	.6	.5	.2
United States	3.4	1.3	1.9	.2

Source:
OECD, 1992.

CONCLUSION

End-of-pipe pollution abatement and control expenditures have been increasing in absolute terms and as a percentage of total investment. These costs represent a lower bound on total PAC expenditures, many of which are impossible to isolate due to the complexity of the investment decision making process. There are no international standards in the definition or measurement of these costs and as a result, comparisons with other surveys should be made with caution.

There is an inherent ambiguity in interpreting PAC expenditures since end-of-pipe outlays are not necessarily the most efficient way to prevent pollution. In many instances, a change in production process leads to a more efficient use of energy and raw materials and reduces the need to install expensive and "non-productive" capital for the purpose of pollution abatement. Since the joint product nature of the problem precludes knowledge of the total costs associated with pollution control, it is useful to know the actual reductions in specific pollutants as well as expenditures on pollution abatement and control.

REFERENCES

Dun & Bradstreet Canada. *Market Survey of Environmental Expenditures by Canadian Business.* Report prepared for Environment Canada. Duns Marketing Services, May, 1991.

Environment Canada. *The State of Canada's Environment.* Ottawa, 1991.

Organization for Economic Cooperation and Development (OECD). *Pollution Abatement and Control Survey 1992.* ENV/EPOC/GEEI(92)11. Preliminary. Paris, 1992.

Statistics Canada, "Analysis of the 1989 Pollution Abatement and Control Survey". Uncatalogued. Investment and Capital Stock Division, Ottawa, 1992.

9 Packaging Use and Disposition

by Marcia Santiago

INTRODUCTION

Packaging material is used to protect, to contain, or to transport commodities. It is also used to market products and to communicate information about products. Most importantly, packaging may protect commodities from damage or spoilage. However, packaging is also associated with a number of environmental concerns, the most prominent of which is the disposal of solid waste.

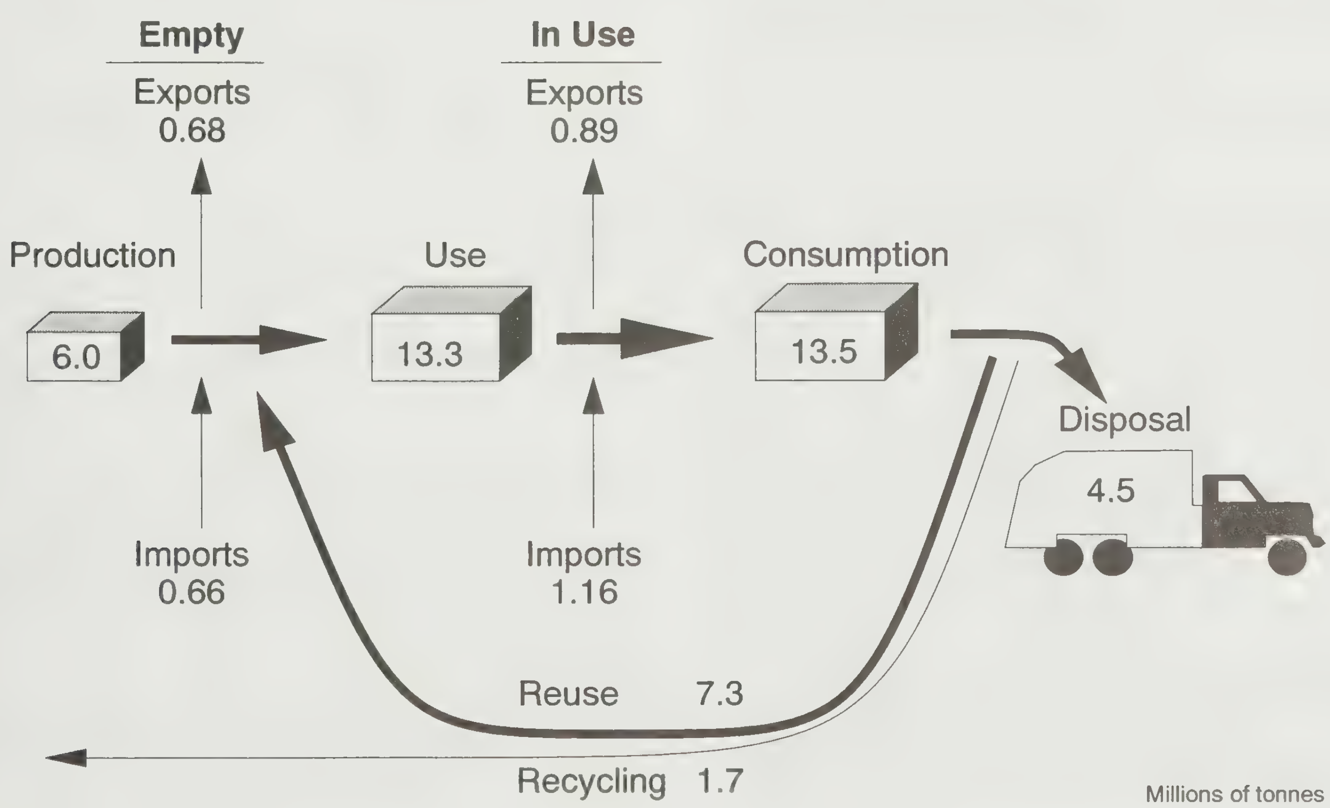
In 1989, Canadian environment ministers gave formal recognition to the need for packaging policy in managing solid waste. The National Packaging Protocol, which resulted from this recognition, recommended six management policies:

- packaging shall have minimal effects on the environment;
- priority will be given to the management of packaging through source reduction, reuse and recycling;
- a continuing campaign of information and education will be undertaken to make all Canadians aware of the function and environmental impacts of packaging;
- these policies will apply to all packaging used in Canada, including imports;
- regulations will be implemented as necessary to achieve compliance with these policies; and
- all government policies and practices affecting packaging will be consistent with these national policies.

Ultimately, the protocol seeks to reduce the quantity of packaging material that is sent to landfills. Over the next few years, diversion targets should be met and, by the year 2000, it is expected that packaging sent for disposal shall not exceed 50% of the 1988 level of 5.3 million tonnes (National Task Force on Packaging, 1992a).

Using results from the 1990 National Packaging Survey (ibid.), this chapter presents a profile of industrial packaging disposition and use. It describes the materials and the users of industrial packaging, with particular attention paid to the use, reuse, recycling and disposal of packaging.

Figure 1: Packaging Flows



PACKAGING FLOWS

Businesses typically handle packaging in conjunction with products they ship and with products they receive. Firms are described here as "using" packaging when it is filled with the product to be shipped whereas both businesses and households are said to have "consumed" packaging when it is removed from the product purchased. The use of packaging is equal to its consumption, except for the quantities attached to imported or exported goods. Since the survey included the waste management industry, estimates are available for the amount of household packaging waste that was recycled in 1990. It is therefore possible to calculate the total disposal for Canada as the difference between consumption and the sum of reused and recycled packaging (see Figure 1).

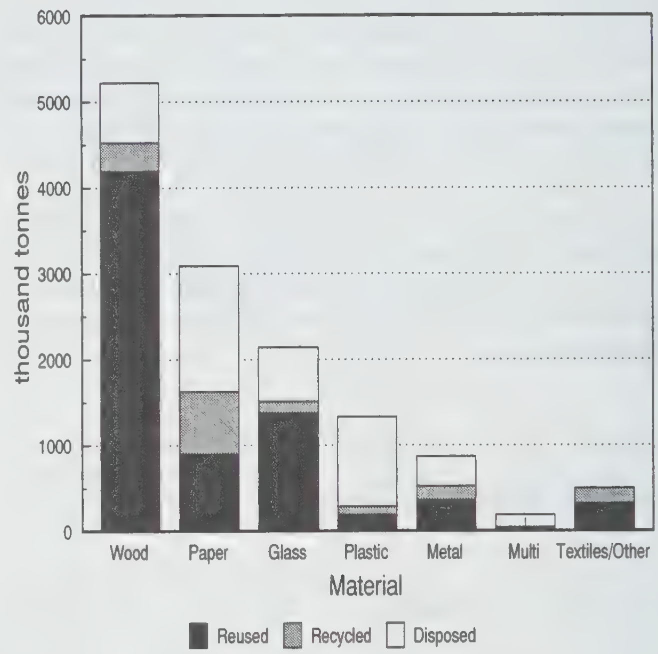
PACKAGING MATERIALS

The consumption of packaging materials amounted to 13.5 million tonnes during 1990 (see Table 1). Wood was the leading material employed, accounting for 39% of the total quantity consumed. Most wood packaging was in pallets, accounting for 4.9 million of the 5.3 million tonnes of wood packaging consumed. Consumption of paper packaging, including cardboard (paperboard) amounted to over 3 million tonnes (23% of the total), with the largest portion consisting of corrugated cartons, boxes and cases. Most goods sold, from food products to electronic equipment, have at least some amount of cardboard or paper packaging attached. Glass and plastic materials made up 16% and 10% of the total packaging consumed in 1990.

Eighty-five percent[1] of wood packaging was estimated to be reused or recycled. Pallets, the largest component of wood packaging, can be used over and over with only occasional minor repairs, so the low disposal of wood is not surprising. Glass also has a high rate of reuse and recycling (69%). For paper and plastic which represent the second and fourth largest volumes of packaging material, the rate of reuse and recycling is lower. Seventy-nine percent of plastic was disposed while 48% of paper was sent to landfills or incinerated. Paper was the largest material by weight to be disposed of. As a percentage of total packaging consumed in 1990, 33% (4.5 millions tonnes) was discarded.

1. The percentages in this paragraph reflect the proportions shown in Figure 2.

Figure 2: Disposition of Packaging, 1990



Sources:
Statistics Canada, National Packaging Survey and National Task Force on Packaging.

Table 1: Consumption and Disposition by Packaging Type, 1990

Material	Types	Total consumed		Total reused		Total recycled		Total disposed	
		thousand tonnes	percent	thousand tonnes	percent	thousand tonnes	percent	thousand tonnes	percent
Wood	pallets, boxes, crates	5 327	39.4	4 187	57.1	335	20.1	805	17.8
Paper	corrugated cartons, boxes, labels	3 149	23.3	899	12.3	723	43.4	1 527	33.7
Glass	carboys, bottles, containers	2 185	16.2	1 373	18.7	136	8.1	676	14.9
Plastic	containers, foam egg trays, wrap, liners	1 358	10.0	190	2.6	95	5.7	1 073	23.7
Metal	aluminum cans, caps, steel strapping	888	6.6	362	4.9	162	9.7	364	8.0
Multi-material	milk and juice cartons	193	1.4	7	--	36	2.2	150	3.3
Textiles and other materials	jute sacks, bags, wrapping	426	3.1	318	4.4	180	10.8	--	--
Total		**13 526**	**100.0**	**7 336**	**100.0**	**1 667**	**100.0**	**4 595**	**100.0**

Sources:
Statistics Canada, National Packaging Survey and National Task Force on Packaging.

PACKAGING USE BY INDUSTRY

The manufacturing sector was the largest user of packaging, accounting for well over 10 million tonnes of the total 13.3 million tonnes used (see Table 2). Manufacturing industries, excluding food, beverage, and tobacco, were least heavily involved in reuse of packaging. Use of packaging material was relatively evenly spaced across the other industry groups, except agriculture, for which use was estimated at 376 thousand tonnes. The estimated packaging use by the wholesale and retail trade industries is not surprising, given their activity of packaging goods and selling them to consumers. Of the important industries in terms of packaging use, the largest percentage of packaging reuse was in the beverage manufacturing industry. This is consistent with the large proportion of glass packaging, which is most commonly used in distributing beverages to consumers.

It is important to note that wooden pallets account for over one-third of all packaging used, by weight, and that there is an economic incentive to reuse these rather than to recycle or discard them. The high reuse of packaging as a percent of use is partly due to this fact. (See Table 2.)

Table 2: Industrial Use and Reuse of Packaging, 1990

Industry	Used (includes reused)		Reused	
	thousand tonnes	percent	thousand tonnes	percent of used
Agriculture	376	2.8	200	53
Manufacturing (excl. food and beverages)	4 287	32.3	1 630	38
Food manufacturing	3 556	26.8	1 444	41
Beverage manufacturing	2 423	18.3	2 076	86
Wholesale and retail trade	2 477	18.7	1 853	75
Other industries	138	1.0	129	93
Total	**13 257**	**100.0**	**7 332**	**55**

Sources:
Statistics Canada, National Packaging Survey and National Task Force on Packaging.

PROVINCIAL CONSUMPTION AND REUSE

The provincial pattern of recycling rates (as a percentage of consumption) is similar to that observed in the Local Government Waste Management Practices Survey (see Chapter 11, Table 3). In both cases, Ontario had the highest rate of recycling followed by British Columbia.

Table 3: Provincial Consumption and Recycling of Packaging, 1990

Province	Total consumed		Recycled	
	thousand tonnes	percent	thousand tonnes	percent of consumed
Newfoundland	166	1.2	--	--
Prince Edward Island	47	0.3	4	9
Nova Scotia	338	2.5	24	7
New Brunswick	295	2.2	13	4
Quebec	3 516	26.0	325	9
Ontario	5 820	43.0	1 065	18
Manitoba	514	3.8	31	6
Saskatchewan	328	2.4	17	5
Alberta	1 130	8.4	41	4
British Columbia	1 356	10.0	144	11
Yukon	5	0.0	0	--
North West Territories	11	0.1	0	--
Canada	**13 527**	**100.0**	**1 664**	**12**

Sources:
Statistics Canada, National Packaging Survey and National Task Force on Packaging.

DATA SOURCES AND METHODOLOGY

In 1991, Statistics Canada conducted the National Packaging Survey. A large representative sample of establishments in all major industry groups was selected. Thirty-two packaging categories were defined in the survey, spanning seven broad groups of materials: plastic, wood, textiles, glass, metal and multi-material packaging. Respondents were asked to report quantities (in tonnes) of packaging that was used during the 1990 calendar year. They were also asked to report the proportions of new and reused content in the materials. Finally, survey respondents were asked to report the quantities of packaging that were reused, recycled and sent for disposal.

Estimates of use, reuse, and recycling of packaging materials presented in this chapter were based upon the responses to the National Packaging Survey described in National Task Force on Packaging (1992b). Certain data collected by the survey were not deemed reliable. For instance, businesses were not generally capable of providing a good estimate of the amount of packaging discarded. Disposal was, therefore, calculated residually. Packaging attached to imports and exports of goods was based on data from the International Trade Division. The exports and imports of in-use packaging were pro-rated in proportion to the packaging used. Imports and exports of new packaging (not attached to goods) came from the International Trade Division of Statistics Canada. These data were available by commodity group and were allocated to industries and provinces on a proportional basis.

Provincial consumption of packaging was not measured directly since inter-provincial trade of in-use packaging was not known. Packaging was assigned to two categories, industrial and consumer. Total Industrial pack-

aging was allocated to provinces according to provincial sales for each industry group, whereas consumer packaging was distributed according to provincial population. Provincial recycling rates for each packaging type and industrial sector were based upon survey data.

For further analysis of these data and for comparisons with the 1988 benchmark levels, see National Task Force on Packaging (1992b). For information on the establishment of the 1988 benchmark see National Task Force on Packaging (1992a).

REFERENCES

National Task Force on Packaging (NTFP). *National Packaging Protocol: 1988 Benchmark Estimates.* Report prepared for the Canadian Council of Ministers of the Environment. Office of Waste Management, Environment Canada. Hull, Quebec, December, 1992a.

National Task Force on Packaging (NTFP), *National Packaging Protocol: Results of the 1990 National Packaging Survey.* Report prepared for the Canadian Council of Ministers of the Environment. Office of Waste Management, Environment Canada. Hull, Quebec, December, 1992b.

10 Waste Management Industry Survey

by Craig Gaston

The waste management industry, which is not officially defined in the 1980 Standard Industrial Classification, includes all establishments that are primarily engaged in the collecting, hauling, recycling or disposing of waste material[1]. This industry is comprised of private companies as well as local government departments. Until recently, the waste management industry has not been surveyed by Statistics Canada. Therefore, two recent surveys covering the private and public components provide important, new information on the industry's structure in Canada. Chapter 11 provides preliminary information from the 1990 Local Government Waste Management Practices Survey and this chapter presents the 1989 Waste Management Industry Survey results.

The 1989 survey gathered information on 643 companies representing some 759 establishments. These establishments accounted for over $1.1 billion in revenues and employed almost 10 000 people. Table 1 shows that almost 72% of industry revenues were earned from collection and haulage of waste, while about 21% came from disposal. In principal, disposal revenues are earned by operators of waste disposal facilities such as landfills, incinerators, etc. There is evidence, however, that some respondents indicated disposal revenues even though they provided only collection and transportation services.

Relatively high disposal revenue shares can be expected in provinces which are characterized by densely populated urban areas where space suitable for new landfills is scarce. This pattern is detectable in Table 1 notwithstanding the exception of Newfoundland. Local government involvement in waste disposal also effects disposal revenues. A relatively high proportion of contractors are responsible for waste disposal in both Quebec and British Columbia according to the Local Government Waste Management Practices Survey[2]. Recycling services and sales of recycled goods accounted for less than 2% of industry income nationally. Even in Ontario, where recycling programs are best established[3], the share of total revenues from this activity was only 2.6%.

In Table 2 the category "Other expenses" contains such costs as depreciation, taxes and professional and contracted services.

Firm size appears to be a significant factor in the pattern of relative costs (see Table 3). Salary and wage costs as a percentage of total revenue increase with declining revenue size whereas tipping expenses show the opposite tendency. Fuel costs show a similar pattern to

1. These establishments are, for the most part, included in the Other Utilities Industry (SIC 4999).

2. See Chapter 11, Table 2.

3. See Chapter 11, Table 3.

Table 1: Revenues by Type of Service and Province, 1989

Province	Establishments	Total revenue	Collection and haulage	Disposal	Recycling	Sales of recycled goods	Sales of energy	Other sales
	number	millions of dollars	percent of provincial revenue					
Newfoundland	28	.9	45.8	46.8	1.4	.1	-	5.8
Prince Edward Island	5	x	x	x	x	x	x	x
Nova Scotia	45	13.2	81.5	13.3	1.7	.3	.4	2.8
New Brunswick	24	4.8	80.7	17.6	.5	.1	--	1.1
Quebec	207	339.6	70.0	22.6	.3	.1	--	7.0
Ontario	222	517.7	70.5	21.3	2.6	.8	.1	4.7
Manitoba	19	14.4	84.7	13.5	.8	.1	.6	.3
Saskatchewan	23	4.6	80.5	12.7	1.9	.1	-	4.8
Alberta	63	91.0	77.1	17.5	2.2	.1	.2	2.9
British Columbia	112	127.8	76.1	19.6	1.0	.1	.1	3.0
Yukon and N.W.T.	11	x	x	x	x	x	x	x
Canada	**759**	**1 119.1**	**71.9**	**20.9**	**1.6**	**.4**	**.1**	**5.0**

Sources:
Statistics Canada, Industry Division and National Accounts and Environment Division.

Table 2: Distribution of Expenses by Province, 1989

Province	Establishments	Total expenses	Tipping fees	Fuel and electricity	Other materials	Salaries and wages	Other expenses
	number	millions of dollars	percent of total expenses				
Newfoundland	28	0.8	2.2	12.9	10.9	46.6	27.5
Prince Edward Island	5	x	x	x	x	x	x
Nova Scotia	45	11.5	18.0	6.5	16.1	27.8	31.5
New Brunswick	24	4.3	6.2	7.2	37.8	30.6	18.2
Quebec	207	284.2	19.5	5.3	22.6	29.3	23.4
Ontario	222	448.8	30.1	4.2	14.6	24.5	26.6
Manitoba	19	12.1	25.3	6.5	6.9	22.1	39.2
Saskatchewan	23	4.1	13.5	9.8	10.8	36.3	29.6
Alberta	63	73.4	17.3	5.0	8.8	28.7	40.1
British Columbia	112	107.8	26.1	4.4	14.0	25.4	30.2
Yukon and N.W.T.	11	x	x	x	x	x	x
Canada	**759**	**952.0**	**24.9**	**4.7**	**16.5**	**26.6**	**27.3**

Sources:
Statistics Canada, Industry Division and National Accounts and Environment Division.

Table 3: Distribution of Expenses by Company Size, 1989

Revenue class	Companies	Total expenses	Tipping fees	Fuel and electricity	Other materials	Salaries and wages	Other expenses
	number	millions of dollars	percent of total expenses				
Greater than $5 million	27	665.2	26.5	3.5	17.2	24.0	28.9
$1 - $4.9 million	100	185.1	26.4	6.2	16.4	30.2	20.7
$.5 - $.9 million	100	59.2	15.0	9.4	11.5	34.5	29.5
Less than $.5 million	416	42.6	8.5	10.6	12.2	40.1	28.6
All companies	**643**	**952.0**	**24.9**	**4.7**	**16.5**	**26.6**	**27.3**

Sources:
Statistics Canada, Industry Division and National Accounts and Environment Division.

salaries and wages. The fact that larger firms are more likely to operate in densely populated urban areas could partly explain the correlation of tipping expense ratios to size.

Table 4: Employment and Salaries by Company Size, 1989

Revenue class of company	Employees	Salaries and wages	Salaries and wages per employee	Salaries and wages/ revenue
	number	millions of dollars	thousands of dollars	percent
Greater than $5 million	6 084	159.6	26.2	20.1
$1 - $4.9 million	1 868	55.9	29.9	26.7
$.5 - $.9 million	897	20.4	22.8	30.5
Less than $.5 million	947	17.1	18.0	34.6
All companies	**9 796**	**253.1**	**25.8**	**22.6**

Sources:
Statistics Canada, Industry Division and National Accounts and Environment Division.

Table 4 shows that about 60% of industry employment is in companies with revenues greater than $5 million.These companies account for over 70% of the total industry revenues. Although a larger proportion of revenues is paid to employees as the firm size diminishes, employees in the smaller firms earn a lower average salary.

This brief profile of the private sector waste management industry is limited by a lack of time series information. The growth of the industry over time and the changing composition of revenues and expenses is a subject of increasing interest as waste management continues to be a focus of public attention. For more information on the 1989 Waste Management Industry Survey see Statistics Canada (1992).

REFERENCES

Statistics Canada. "1989 Waste Management Survey". Uncatalogued. Industry Division, Ottawa, 1992.

11 Local Government Waste Management Practices Survey

by Craig Gaston and Alan Goodall[1]

INTRODUCTION

This chapter provides a preliminary report of some results from the national Local Government Waste Management Practices Survey. This survey sampled municipalities of all types and some special purpose boards known to be heavily involved in waste management. While questionnaires were mailed to a total of 1000 local government entities, data presented here reflect only 83 lower-tier municipalities[2] that had a population of greater than 50 000 in 1991. These 83 entities accounted for about half of the Canadian population.

The survey, the first of its kind for Statistics Canada, contained a number of questions designed to profile the practices of local governments with respect to the collection, transportation and disposal of garbage, as well as recycling and the handling of hazardous waste. As a pilot study, it was intended to obtain an overview of the structure and function of Canadian local government activities pertaining to waste management. Toward this end, the surveyed sample included every type of local government believed to have some responsibility for waste management. Questions were asked to determine whether the various functions were performed by the municipality surveyed, by contractors, or by another level of government. Information was also sought on a number of other items, including costs associated with waste management. A comprehensive examination of financial and other data is to be released in the final full survey report.

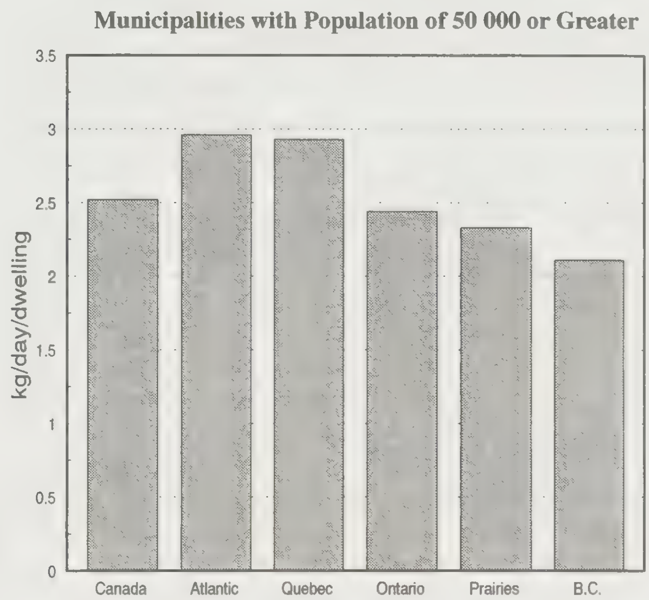
RESULTS

Based upon the total annual quantities reported, the 83 municipalities collected, on average, slightly over 0.9 tonnes of residential garbage[3] per dwelling served or about 2.5 kilograms per day (see Figure 1). Seventy-three of these municipalities reported having a recycling program, through which approximately 9% (by weight) of the total waste[4] stream was recycled. (This excludes private contracts by apartment building operators.)

Fifty-six of the municipalities had some form of residential hazardous waste program while only 10 had a program for non-residential hazardous wastes.

Thirty-six of the municipalities reported having arranged for waste composition studies, an important step towards effective waste management. In addition, 53 of the municipalities had some form of waste reduction program (public education, for example, but not recycling).

Figure 1: Garbage Collected per Dwelling, 1990



Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Collection

Waste collection is primarily a function of lower-tier governments, frequently involving both contractors and municipal employees. Eighteen municipalities (22%) reported using only their own employees for this purpose and 40 (48%) reported hiring only contractors (see Table 1). On a regional basis, only 5% of Quebec respondents had their own employees performing this function while 84% of them used only contractors. Municipalities within census metropolitan areas (CMAs) or census agglomerations (CAs) with populations of less than 500 000 tended to use their own employees while those in CMAs or CAs greater than 500 000 relied more on contractors.

1. The authors would like to thank Don Kerr for his painstaking work in assuring the quality of the data.

2. See the section titled: "Local Government: Upper and Lower Tiers".

3. On the questionnaire, garbage is defined as non-hazardous waste excluding materials diverted to a recycling program.

4. Waste is defined as any substance discarded for final disposal or recycling for which the owner or generator has no further use.

Table 1: Garbage Collection by Agent Responsible, Municipality Size and Region, 1990

	Population of CA/CMA to which municipality belongs				Region				
	50 000 - 499 999	500 000 - 999 999	1 000 000 and over	**Canada**	Atlantic Provinces	Quebec	Ontario	Prairie Provinces	B.C.
Number of municipalities reporting	37	14	32	**83**	5	19	37	7	15
Agent responsible for collection	percent of municipalities reporting								
Municipal employees only	32	14	13	**22**	40	5	27	14	27
Contractors only	30	64	63	**48**	40	84	41	14	40
Municipal employees and other	5	0	3	**4**	0	0	0	29	7
Municipal employees, other levels of government and other	3	0	0	**1**	0	0	3	0	0
Municipal employees and contractors	24	21	22	**23**	20	11	27	43	20
Municipal employees, contractors and other	5	0	0	**2**	0	0	3	0	7
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Table 2: Garbage Disposal by Agent Responsible, Municipality Size and Region, 1990

	Population of CA/CMA to which municipality belongs				Region				
	50 000 - 499 999	500 000 - 999 999	1 000 000 and over	**Canada**	Atlantic Provinces	Quebec	Ontario	Prairie Provinces	B.C.
Number of municipalities reporting	37	14	32	**83**	5	19	37	7	15
Agent responsible for disposal	percent of municipalities reporting								
Municipal employees only	35	21	6	**22**	60	11	16	71	13
Contractors only	24	0	44	**28**	0	58	14	29	33
Other levels of government only	30	64	44	**41**	40	32	57	0	33
Contractors and other levels of government	3	7	3	**4**	0	0	5	0	7
Municipal employees and other	3	0	0	**1**	0	0	3	0	0
Municipal employees and other levels of government	3	7	0	**2**	0	0	3	0	7
Municipal employees and contractors	3	0	3	**2**	0	0	3	0	7
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Disposal

Upper-tier governments play a much more important role in waste disposal than they do in collection. Thirty-three of the municipalities (41%) indicated that this function was handled solely by other levels of government (see Table 2). Contractors were exclusively involved in waste disposal for 23 (28%) of the municipalities while 18 (22%) used only their own employees. Again, population size is a factor as the municipalities within a CMA or CA having a population of under 500 000 tended to rely more on their own employees, whereas those within CMAs or CAs with a population greater than 500 000 contracted the function or relied more heavily on the upper tier. Regionally, Quebec municipalities tended to rely more on contractors for disposal while disposal programs were run most frequently by upper-tier local governments in Ontario.

Recycling Programs

Seventy-three municipalities (88%) reported having an organized recycling program (of which 54 provided details) (see Table 3). In all size groups and regions, the percentage of respondents with recycling programs was quite high, ranging from a low of 74% in Quebec to 100% in the Prairies. Both collection and preparation for sale of recyclable[1] materials are most often handled by contractors (see Tables 4 and 5). Municipal employees play a much smaller role in

Table 3: Recycling Programs and Percent of Waste Recycled by Municipality Size and Region, 1990

	Population of CA/CMA to which municipality belongs				Region				
	50 000 - 499 999	500 000 - 999 999	1 000 000 and over	**Canada**	Atlantic Provinces	Quebec	Ontario	Prairie Provinces	B.C.
Number of municipalities reporting	37	14	32	**83**	5	19	37	7	15
	percent								
Municipalities with recycling program	86	93	88	**88**	80	74	97	100	80
Waste recycled as a proportion of total waste collected	9	7	10	**9**	4	5	13	6	10

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Table 4: Collection of Recyclable Materials by Agent Responsible, Municipality Size and Region, 1990

	Population of CA/CMA to which municipality belongs				Region				
	50 000 - 499 999	500 000 - 999 999	1 000 000 and over	**Canada**	Atlantic Provinces	Quebec	Ontario	Prairie Provinces	B.C.
Number of municipalities reporting	37	14	32	**83**	5	19	37	7	15
Agent responsible for collecting recyclable materials	percent of municipalities reporting								
Municipalities' employees only	11	14	22	**16**	20	5	22	14	13
Contractors only	46	36	56	**48**	40	58	57	14	33
Other levels of government only	8	21	6	**10**	0	5	14	0	13
Other only	14	7	0	**7**	20	5	0	29	13
Contractors and other	8	0	0	**4**	0	0	3	14	7
Municipal employees and contractors	0	7	3	**2**	0	0	3	14	0
Municipal employees, contractors and other	0	7	0	**1**	0	0	0	14	0
Municipal employees, contractors and other levels of government	3	0	0	**1**	0	0	3	0	0
No program	11	7	13	**11**	20	26	0	0	20
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

these functions compared to general waste management. Other organizations (primarily volunteer organizations and private enterprises) also play an important part in recycling operations. Upper-tier local governments tend to be more involved in the handling and preparation for sale of recycled materials than in their collection.

Table 6 shows the percentage of municipalities offering a recycling program for each of the nine materials listed by type of collection service offered. Percentages are based upon information from the 54 respondents reporting the detail of their programs. All of the municipalities reported newsprint recycling for low density dwellings. As one might expect, the frequency of such programs decreases as the density of dwelling increases since the logistics of coordinating recycling programs for multiple unit dwellings may be more complex. The fourth column in Table 6 shows the percentage of local governments offering a depot recycling program. It should be noted that the existence of a program for compostable materials does not mean all possible materials in this category are collected. In some cases municipalities have reported collecting only Christmas trees.

Hazardous Waste Programs

Fifty-six (67%) of the municipalities reported they had a residential hazardous waste program. Ontario had the highest regional representation, with 95% of municipalities reporting some type of program (see Table 7). Note that for this survey, once-per-year household hazardous waste drop-off programs qualified as valid responses.

1. Material which, technically, can be reused as a raw material in the manufacture of a new product.

Table 5: Sorting and Preparing of Recyclable Materials for Sale by Agent Responsible, Municipality Size and Region, 1990

	Population of CA/CMA to which municipality belongs				Region				
	50 000 - 499 999	500 000 - 999 999	1 000 000 and over	**Canada**	Atlantic Provinces	Quebec	Ontario	Prairie Provinces	B.C.
Number of municipalities reported	37	14	32	**83**	5	19	37	7	15
Agent responsible for sorting/preparing recyclable materials	percent of municipalities reporting								
Municipal employees only	5	7	0	**4**	20	0	3	14	0
Contractors only	41	50	47	**45**	40	58	43	43	33
Other levels of government only	19	21	22	**20**	0	11	35	0	13
Other only	16	14	3	**11**	20	5	3	43	20
Contractors and other	5	0	0	**2**	0	0	3	0	7
Contractors and other levels of government	3	0	0	**1**	0	0	3	0	0
Other levels of government and other	0	0	3	**1**	0	0	3	0	0
Municipal employees and other levels of government	0	0	3	**1**	0	0	3	0	0
No program	11	7	22	**14**	20	26	5	0	27
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Backyard Composting

Thirty-two municipalities (39%) indicated that a backyard composting program existed within their boundaries. Of these, 28 provided data on the number of composters distributed. As reported, over 83 000 composters had been distributed. Thirty percent were supplied by the municipality, 17% by contractors, 42% by other levels of government, with the remainder supplied by other organizations.

Table 6: Recycling Collection Programs and Depots, 1990

Recyclable Material	Recycling collection program: Low density dwellings	Medium density dwellings	High density dwellings	Depots
	percent			
Newspaper	100	61	37	54
Cardboard	50	30	20	35
Fine paper	20	7	4	28
Glass	96	59	35	41
Ferrous metal	85	50	30	39
Non-ferrous metal	76	48	33	37
Plastic	67	37	30	37
Compostable materials	33	17	9	13
Used motor oil	15	7	2	13

Note:
Based on detailed information provided by 54 municipalities that provided details of their recycling programs.
Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Disposal Facilities

Information was provided for 165 of the disposal facilities used by respondents (see Table 8). Sanitary landfills are the most commonly reported means of waste disposal for municipalities with a population of 50 000 and over. However, not all the sites (as described by respondents) appear to meet the criteria set for sanitary landfills. At a minimum, in addition to frequent and regular coverage of waste, a sanitary landfill must have either a natural or an artificial liner to prevent leachate from contaminating groundwater.

Of the 100 landfills reported, some detailed characteristics were provided for 60 sanitary landfills within local municipal boundaries (see Table 8). As reported, in addition to frequent coverage of waste, these sites had the attributes shown in Table 9.

DATA QUALITY

Completed questionnaires were received for all of the 83 lower-tier governments reported here. Most of these were contacted by telephone in order to clarify responses, correct inconsistencies and obtain missing information. As a result of this follow-up, data on the availability of programs and the agent responsible for their delivery is considered to be very accurate. The more detailed information on characteristics of disposal sites is of lower quality because not all municipalities were able to provide these data. Population counts were verified using information from the 1991 Census of Population.

Table 7: Hazardous Waste Program by Type of Program, Municipality Size and Region, 1990

	Population of CA/CMA to which Municipality Belongs				Region				
	50 000 - 499 999	500 000 - 999 999	1 000 000 and over	**Canada**	Atlantic Provinces	Quebec	Ontario	Prairies Provinces	B.C.
Number of municipalities reporting	37	14	32	**83**	5	19	37	7	15
	percent of municipalities reporting								
Residential	70	64	66	**67**	20	42	95	86	40
Non-residential	16	29	0	**12**	20	0	8	43	20

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Table 8: Garbage Handling and Disposal Facilities, 1990

Type of facility as reported by respondent	Number	Percent
Sanitary landfills	100	61
Other landfills	5	3
Volume reduction facilities (e.g. incinerators)	7	4
Material recovery facilities	7	4
Transfer stations	46	28
Quarry dumps	.	.
Total	**165**	**100**

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Table 9: Sanitary Landfills by Characteristics Reported, 1990

	Number reported			
Characteristic	Yes	No	No answer	Total
Presence of weigh scales	48	11	1	**60**
Natural attenuation	27	9	24	**60**
Artificial liner	17	35	8	**60**
Leachate collection system	29	27	4	**60**
Methane gas harnessing system	11	41	8	**60**

Sources:
Statistics Canada, Public Institutions Division and National Accounts and Environment Division.

Data were requested for the fiscal year ending nearest December 31, 1990 but many respondents reported programs implemented subsequent to that date. As it was not possible to correct for this tendency, some percentages are higher than would be expected for the reporting period requested. An analysis of responses to the recycling question indicates that the impact is greatest on local governments with the smallest population. There does not appear to be a regional bias to this tendency.

LOCAL GOVERNMENTS: UPPER AND LOWER TIERS

Local government in Canada includes all government entities below the provincial/territorial level which, by the terms of their establishment, do not form part of the provincial/territorial level. Within this broad category, structures and responsibilities of local governments are further divided between municipalities, special purpose boards and local school districts. Municipalities are subdivided into unitary, regional and quasi-municipalities. To prevent double-counting, these municipalities were further classified into upper and lower-tier. For the purposes of this survey, upper-tier municipalities are those encompassing one or more local government entities. Lower-tier municipalities are those within the jurisdiction of another municipality type.

Upper-tier municipalities typically include metropolitan corporations, regional districts, regional municipalities, and counties (in Ontario and Quebec). Lower-tier municipalities include cities, towns, villages, townships, rural municipalities, districts and counties (in Nova Scotia and Alberta), and some quasi-municipalities (e.g., local government districts, local improvement districts).

12 Materials Recovery and Recycling by the Industrial Sector

by Marcia Santiago

INTRODUCTION

Recycling is not new and neither is it limited to households. Industry has been active in recycling for some time. The materials collected for industrial reuse are broadly similar to those collected from households: metals, paper, glass and plastics.

From an environmental standpoint, there are some beneficial aspects to the manufacturing of metal products from recycled material rather than from ores or concentrates. First, producing components from scrap material, rather than from primary metal results in savings of 75-95% of energy costs (Chandler, 1990). In addition, considerably less pollution is released.

There are three essential components in a cost-effective recovery and recycling system: supply, technology and markets. The source of recovered material must be readily accessible and reliable. An efficient collection network is especially important in this regard. There must also be in place sufficient technological capability to reprocess recovered materials. Most importantly, the demand for the reprocessed materials must be well developed.

This chapter attempts to compare virgin and scrap material prices, in order to describe their relative behaviour in changing markets. In general, differences in movements of virgin and scrap prices are expected to reflect the overall pattern of manufacturing activity. In cases where there are no regulatory pressures, market forces dictate the extent to which scrap is used. For metals, the difference between scrap and ore price movements would reflect the relative energy demand of primary and secondary manufacturing depending on the quality of ore that is available.

PULPWOOD AND NEWSPRINT

Although environmental regulations and recently increased customer demand have focused attention on the recycled fibre content in paper, material recovery is actually a long-standing practice in the pulp and paper industries. Pulpwood chips, a by-product generated by sawmills in the processing of timber to lumber, are an alternative to logs and bolts in the production of pulp. Similarly, newsprint and fine paper may be used as recycled fibre content, in the production of either other printing and writing paper or paperboard and boxboard.

Chipping is a natural extension of the sawmill business, as it is an efficient way of handling the large volumes of pulp wood debris that accumulate. One consideration in handling such waste, which usually consists of short log ends and chunks, is the distance that the chips must be hauled from the sawmill to the pulp mill. A chipping operation may, by some estimates, reduce wood debris by almost half (Phillips, 1992). These chips are eventually used in the production of pulp, newsprint and other paper products (Table 1).

Table 1: Selected Material Inputs to Pulp and Paper Products, 1987

Commodity inputs	Commodities produced			
	Pulp	Newsprint	Paperboard and building board	Paper boxes, bags and containers
	millions of dollars			
Pulpwood	504	676	54	--
Pulpwood chips and other wood waste	784	313	82	--
Pulp	85	261	237	9
Miscellaneous paper	22	70	539	2 209
Total	**1 395**	**1 320**	**912**	**2 218**

Source:
Statistics Canada, Input-Output Division

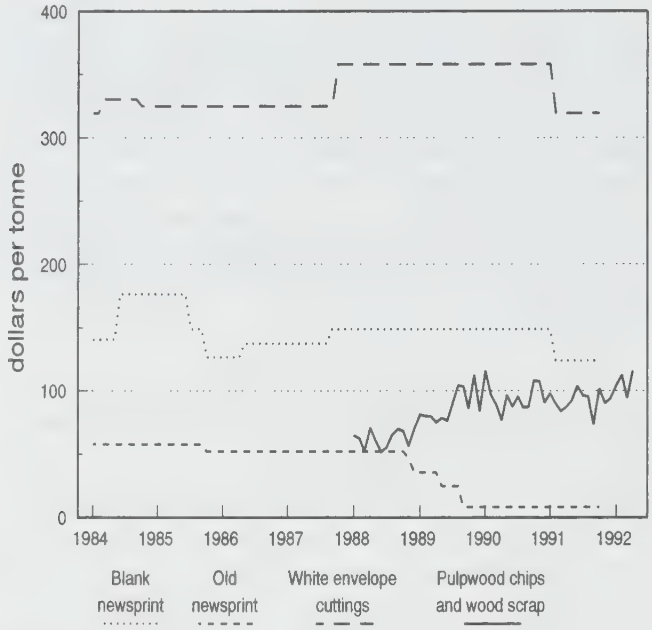
Markets for paper containing recycled fibre continue to grow. This is especially true in newsprint, despite recurring technical problems like "stickies" — a buildup of residual ink on the paper machine that requires a great deal of cost and effort to control. The development of markets for fine paper is also well under way. A Mississauga, Ontario firm was the first to supply customers with paper that contained fibre from its own wastepaper supply (Hedlund, 1992).

Unit prices[1] for some of these materials are shown in Figure 1. While the price of old newsprint has been well below that of unprinted scrap newsprint since mid-1988, the price for old newsprint began to fall about one and a half years ahead of the price for unprinted scrap newsprint. In contrast, prices for pulpwood chips and scrap wood actually increased until January 1990, when they reached their peak value of $116 per tonne. More recently, the United States has been tightening up its regulatory framework, re-

1. Unless otherwise specified, unit prices quoted in the text are based on October 1991.

quiring a higher recycled material content in newsprint and this may lead to higher prices in the longer term.

Figure 1: Scrap Wood and Paper Products, Monthly Unit Prices, 1984-1992



Sources:
Statistics Canada, International Trade Division.
Recoup Publishing Limited.

ALUMINUM

Between 1988 and 1990, production of secondary aluminum in market economies set record volumes of about 5.1 million tonnes. These high volumes are attributed to continuing improvements in the scrap collection system and increased recycling promotion by governments and environmental groups (EMR, 1991). This is especially true of used beverage cans.

Table 2: Aluminum Production and Trade, 1989

	Quantity	Value
	thousand tonnes	million dollars
Total Canadian production	1 555	...
Imports		
Aluminum ore and concentrate	2 541	111
Aluminum oxide	2 031	629
Aluminum waste and scrap	58	93
Exports		
Aluminum, not alloyed	614	1 450
Aluminum alloys	544	1 356
Aluminum waste and scrap	164	328

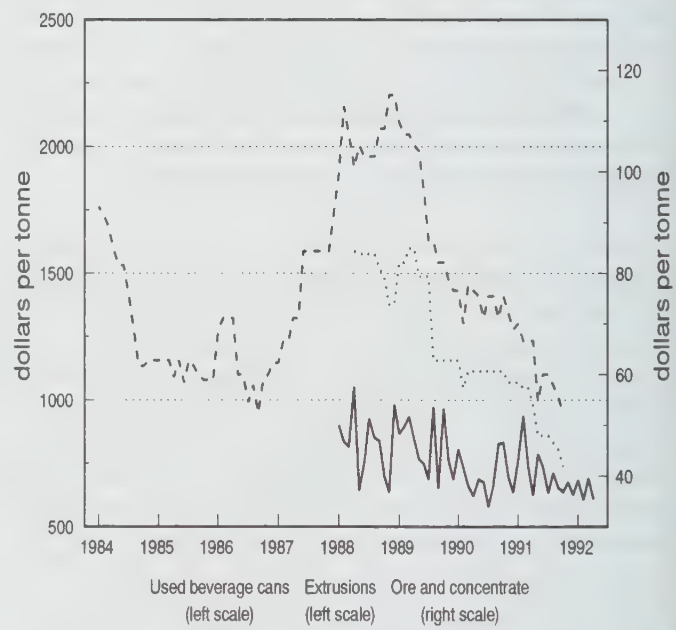
Source:
Energy Mines and Resources Canada, 1991.

In 1989, aluminum scrap represented a total of $328 million or 164 thousand tonnes in exports (Table 2). This mainly consisted of material recovered from industrial processes. Another source of aluminum scrap is consumer durable goods, which include pots, pans, flatware, appliances, as well as transportation equipment components. Packaging is also a large component of aluminum scrap; used beverage cans are the most common example.

Aluminum can scrap is used by both primary and secondary aluminum producers (Selke, 1990). The first step in recycling of aluminum cans is usually a preliminary screen with a magnet to remove any steel cans inadvertently mixed in. The cans are next shredded to one-inch pieces. Fines and dust are collected and removed by high efficiency cyclones to eliminate any explosion hazard. Magnets are again used to remove any steel scraps. Most other contaminants, such as paper, are removed in pneumatic processing. Finally, the aluminum scrap is charged in the furnace, where alloy composition is adjusted as required.

Compared to other nonferrous metal scrap, the unit prices for various grades of recovered aluminum are quite high (Figure 2). They range from $738 per tonne for used beverage cans to $947 per tonne for aluminum extrusions. This is also considerably higher than the unit value of aluminum ore and concentrate ($37 per tonne).

Figure 2: Aluminum Ore, Scrap and Extrusions, Monthly Unit Prices, 1984-1991



Note:
"Extrusions" refers to industrial scrap aluminum.
Sources:
Statistics Canada, International Trade Division.
Recoup Publishing Limited.

Part of the price difference between aluminum ore/concentrate and recovered aluminum is related to a basic cost issue: compared to one produced from ore or concentrate, a product manufactured from a recovered source of aluminum requires less energy. Because of the high energy requirements for refining aluminum ores, energy accounts for about one fifth of the cost of producing aluminum from ore (Chandler, 1990). Use of recycled aluminum represents an overall cost savings of about 40%.

However, the market for recycled packaging is subject to a number of stresses. First, aluminum is a somewhat more expensive packaging material than steel for producing beverage cans. In Ontario, some of the major soft drink manufacturers have begun to use cheaper bimetal cans. Although these alternatives may be used in steel recycling, they could pose problems for programs that depend on the more lucrative aluminum cans to fund other aspects of the recycling facility. Another factor is an environmental levy imposed on beer cans, to which some manufacturers of aluminum cans have attributed a recent drop in sales.

IRON AND STEEL

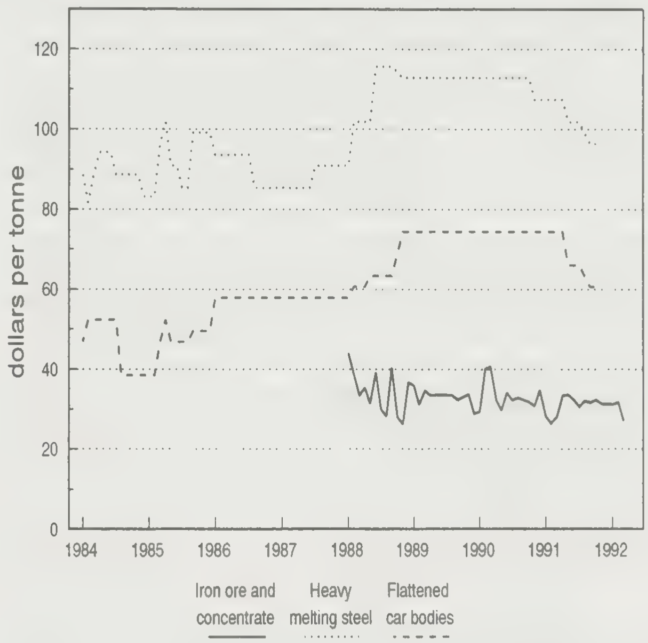
Ferrous scrap is used in steel produced in electric furnace mills and integrated mills. Foundries are also a large market for iron and steel scrap. In turn, automotive manufacturers are these industries' primary markets. As such, Canadian scrap prices often fluctuate with the pattern of growth in these industries. For example, activity in these industries has been slack recently and that pattern is reflected in the prices of steel scrap.

In Canada, new scrap averaged 17% of total finished steel and represented 60% of total purchased scrap (Stollery, 1983). High grade ferrous scrap competes directly with pig iron in steel furnaces because it can be used without intermediate smelting or refining. Thus, the price of ferrous scrap may be expected to vary positively with steel output. Stollery shows that changes in the price of ferrous scrap affect the demand for iron ore, which is also influenced by increases in the output of steel in the U.S.

Several grades of ferrous scrap are traded in secondary markets and two examples are shown in Figure 3. Heavy melting steel, valued at $96 per tonne, consists of wrought iron and steel segments that are at least four inches thick. Black and galvanized steel scrap, clippings, old auto bodies and fenders are all compressed to bundles of fixed sizes. Depending on the impurities, bundled scrap, as it is called, also has several grades. In late 1991, flattened car bodies were priced at $61 per tonne.

Prices for both iron ore and ferrous scrap (heavy melting steel and flattened car bodies) have been stable since the middle of 1988. Price changes for these commodities are shown in Figure 3. Scrap prices increased steadily from the beginning of 1984, when prices ranged from $47 per tonne to $89 per tonne, to the latter part of 1988, when they reached $74 per tonne to $113 per tonne. These prices, however, have felt the effect of recession. By the latter part of 1991, they had fallen well below the 1988 level.

Figure 3: Iron Ore and Scrap Steel, Monthly Unit Prices, 1984-1991



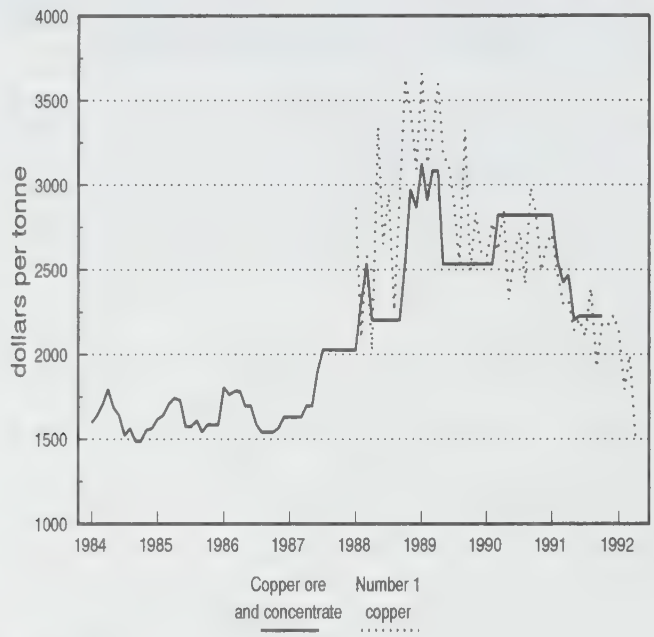
Sources:
Statistics Canada, International Trade Division.
Recoup Publishing Limited.

COPPER

A comparison of monthly copper ore and scrap unit prices is shown in Figure 4. Since 1984, the price movement has been similar to that of other primary and secondary metals. However, the unit price of copper ore and concentrate is about the same as that of Number 1 copper scrap, which is at least 96% pure copper and valued at $2.22 per kg. This is quite different from the pattern shown by iron and aluminum. It reflects differences in the quality of ores and concentrates that are traded. There is also a range of lower grade, refinery brass and smelter copper, whose prices range from $0.88 per kg to $1.83 per kg.

Historically, Stollery (1983) has shown that the prices of scrap copper have followed the pattern of activity in U.S. and European durable goods manufacturing. Although there are considerable differences in the energy requirements of primary and secondary copper production, the availability of fairly high-grade virgin material has maintained the relative market positions of ore and scrap.

Figure 4: Copper Ore and Scrap, Monthly Unit Prices, 1984-1991



Sources:
Statistics Canada, International Trade Division.
Recoup Publishing Limited.

DATA SOURCES

Price data for pulpwood chips, as well as metal ore concentrates, are based on quantity-weighted averages of import/export values. At the time of writing, time series based on the Harmonized Commodity Description and Coding System were available for the period September 1988 to April 1992. These are values declared at Customs, rather than announced or actual producer or purchaser prices. This is the most easily accessible source of non-confidential unit prices.

Price data for recovered materials were taken from a series of publications (Recoup). From this series, the most recent available issue was for October 1991 prices. In all cases, these are announced broker prices. Prices shown are specific to certain regions: Northeastern U.S. and Southern Ontario (used beverage cans), Ontario (ferrous scrap) or Toronto (other nonferrous scrap, paperstock). There may be quite a large difference between the announced prices and the discounted ones.

REFERENCES

Chandler, W.U. *Materials Recycling: The Virtue of Necessity* in S.E. Selke. *Packaging and the Environment: Alternatives, Trends and Solutions.* Lancaster, Pa: Technomic, 1990.

Energy Mines and Resources (EMR). *1990 Canadian Minerals Yearbook: Review and Outlook.* Catalogue M38-5/39E, Ottawa, 1991.

Hedlund, J. "Recycling Kicks Into High Gear". *Pulp & Paper Canada* 93(4):11, 1992.

Phillips, P.J. "At The Cutting Edge of Smallwood Pulping." *Pulp & Paper Canada* 93(5):37-38, 1992.

Recoup Publishing Limited. *Materials Recycling Markets.* Chesterville, Ontario. Monthly issues from 1988 to 1991.

Selke, S.E. *Packaging and the Environment: Alternatives, Trends and Solutions.* Lancaster, PA: Technomic, 1990.

Stollery, K.R. *Secondary Supply of Copper and Ferrous Metals and Canadian Metal Markets.* Technical Paper No. 3. Kingston, Ont.: Centre for Resource Studies, Queen's University, 1983.

13 Preliminary Estimates of the Value of Crude Oil and Natural Gas Reserves in Alberta

by Alice Born

INTRODUCTION

Economically recoverable sub-soil mineral deposits are wealth assets and not merely "free gifts of nature" as they are presently treated by conventional methods of national accounting. Thus, there is no national accounting for the total value of Canada's renewable or non-renewable natural resources and their physical depletion. Currently, the value of Canada's natural resources is excluded from Canada's National Balance Sheet Accounts, thus underestimating Canada's wealth.

This article presents preliminary results from a pilot study of the value of Alberta's crude oil and natural gas reserves. Statistics Canada proposes to include the value of Canada's natural resources in the National Balance Sheet. The development of *physical* accounts will provide a consistent national set of estimates of Canada's natural resource base, while the development of *monetary* accounts will provide a conceptual framework for monetary valuation of Canada's natural resources and their economic depletion.

Why should we measure the monetary value of Canada's natural resource endowment? Firstly, the use of natural resource assets generates substantial amounts of revenue and makes an important contribution to Canada's economic activity. The monetary accounts will provide an indication of the size of this income-generating potential. Secondly, monetary valuation of our natural resources provides a tool that allows us to compare Canada's net worth (assets - liabilities) to other industrialized countries without such natural resource endowments. The national balance sheet provides a total picture of a country's tangible and financial wealth thus aiding intertemporal and international economic structural comparisons. Thirdly, evaluation of a nation's future potential for sustained income generation can be enhanced by detailed analysis of national and provincial assets and liabilities. Revenues from non-renewable resources (e.g. royalties and land costs) may be converted into other assets capable of providing an ongoing return through savings and investment. An accounting representation should recognize that one kind of asset can be exchanged for another, the sale of a natural resource is exchanged for the acquisition of a new income-producing asset and the loss of the natural resource extracted. There is also public concern about the availability of mineral resources needed to sustain economic growth. Will resource availability seriously constrain the high standards of living in developed countries and the economic growth of the developing countries? It is hoped that natural resource accounting will address some of these issues.

Natural resource accounts can be used to measure the interrelationship between the economy and the environment. The focus of traditional systems of national accounts on market transactions in the economy has excluded accounting for changes in the quality of the environment and the stock and depletion of natural resources. Initiatives have been taken by the United Nations and several countries on satellite accounting for the environment in the System of National Accounts (SNA) in order to account for environmental and natural resources such as air, water, land, forests and sub-soil mineral deposits. The current revision to the SNA by the United Nations presents an opportunity to examine how natural resource accounting can be *linked to* or *incorporated in* the SNA (Bartelmus, 1991). In measuring sustainable development, there is a need to fully account for the use of both man-made and natural capital in order to recognize the possibility of non-sustainable growth and development (Bartelmus *et al*, 1991). The proposed SNA framework extends the concept of capital assets to cover both.

Only those reserves capable of producing economic benefits to their owners with current technology, scientific knowledge and relative prices and costs at the date to which the Balance Sheet relates will be included in the physical and monetary accounts. These natural resources have a high probability of being used in production of goods and services. Known reserves of oil and natural gas reserves that are not commercially exploitable in the foreseeable future are excluded from that Balance Sheet Accounts. These reserves may possibly become economical as the result of new technologies or major changes in relative prices similar to those of the oil shocks in the 1970s and 1980s. Accordingly, the physical and monetary accounts record, for any given year, the value of resources known to exist in that year, and to be economically viable given the technologies available in that year, all evaluated at the prices and costs prevailing in that year.

In December 1990 the Federal Government released *Canada's Green Plan*. Some of the initiatives from the *Green Plan* include: updating estimates of all natural resource stocks; increasing monitoring programs on the uses of renewable and non-renewable resources; and identifying the value of Canada's natural resources. Statistics Canada's role is to provide statistical information that integrates economic and environmental elements so that, for example, the value of natural resources is reflected in the Canadian System of National Accounts. Two pilot projects in natural resource accounting have been initiated by the

National Accounts and Environment Division at Statistics Canada. One considers a non-renewable resource, crude oil and natural gas reserves, and the other involves a renewable resource, timber.

This work on the development of natural resource accounts is part of the continuing work to complete the Canadian System of National Accounts (CSNA). The CSNA is one of the most complete national accounting systems in the world. The National Balance Sheet is only one component of this system and it provides estimates of Canada's wealth. When partial estimates of non-financial assets were first published as part of the National Balance Sheet in 1985, it was intended that further work be undertaken to complete the balance sheet by including other non-financial assets such as renewable and non-renewable resource assets.

This chapter presents both physical and monetary accounts for the crude oil and natural gas reserves of the Province of Alberta from 1961 to 1990. It is a shorter version of an earlier discussion paper (Born, 1992). For a more theoretical and expanded discussion, readers are referred to this previous paper.

THE OIL AND NATURAL GAS SECTOR IN ALBERTA

Alberta is the largest producer and owner of economically recoverable reserves of crude oil and natural gas in Canada. At the end of 1990, there were 530 million cubic metres of conventional crude oil reserves in Alberta, representing 60% of Canada's remaining established reserves of conventional crude oil, 1.7 billion cubic metres of marketable natural gas (62% of the Canadian total) and 524 million cubic metres of developed crude bitumen (100% of the Canadian total) (Canadian Petroleum Association, 1990; and Alberta Energy Resources Conservation Board, 1990).

The value of Alberta's production of conventional crude oil, natural gas and their associated by-products was $15.5 billion in 1990 or 83% of the value of Canada's total petroleum production (Statistics Canada, 1990). The value of Alberta's production from non-conventional sources (e.g. tar sands) was $2.8 billion, representing all of Canada's synthetic crude oil and bitumen production in 1990.

The upstream oil and natural gas sector is a capital intensive activity. Annual capital (namely exploration and development) expenditures in Alberta increased from $272 million in 1961 to $4.0 billion in 1990. Net fixed capital stock estimates for the sector have increased from $1.6 billion to $33.6 billion in that same period.

Royalties, and land acquisition costs and rental fees totalled $154 million in 1961 and $3.7 billion in 1990 for the province. Operating costs for extraction of oil and natural gas totalled $124.0 million in 1961 and increased to $4.8 billion in 1990.

Since most of Canada's petroleum production and remaining reserves are located in Alberta, this province has been examined first. Valuation models developed for Alberta's conventional reserves of crude oil and natural gas reserves are extended to other areas of Canada with oil and natural gas reserves and Alberta's non-conventional reserves of crude bitumen and will be published at a later date.

DEFINITION OF MINERAL RESERVES AND RESOURCES

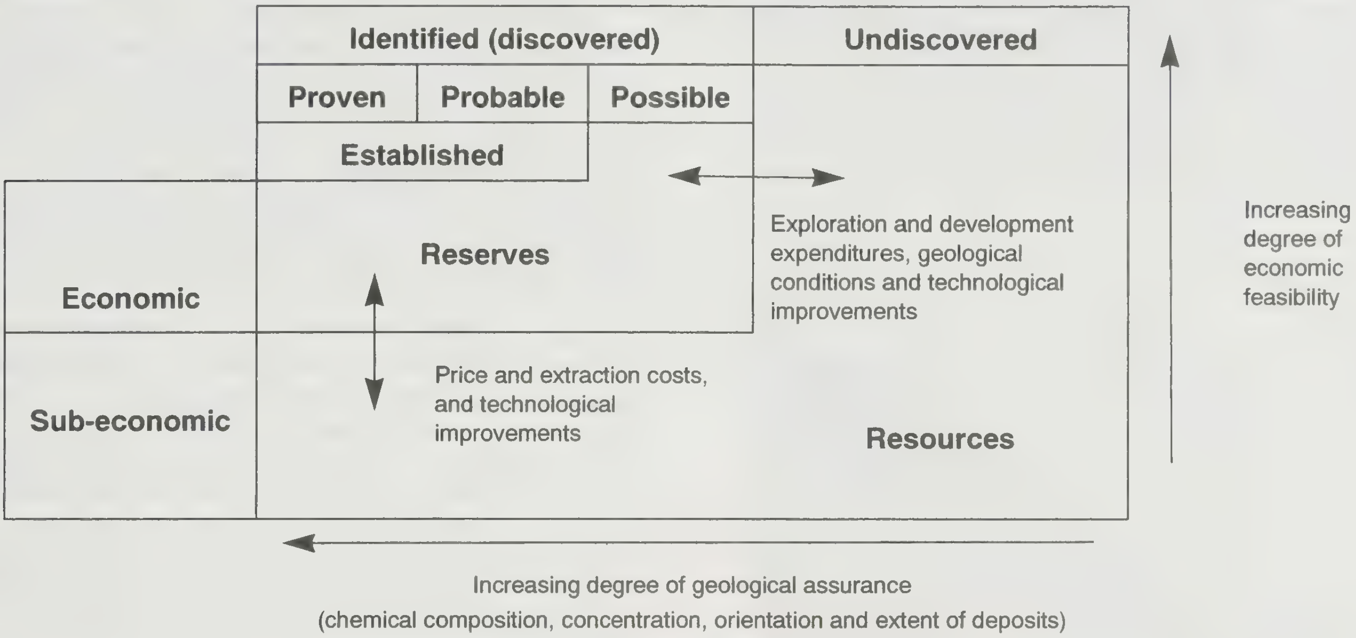
Estimates of the size of reserves of non-renewable (exhaustible) resources are continually being revised. In the development of physical accounts, the McKelvey Box is used to distinguish mineral resources from mineral reserves and to show what factors affect the size of the reserves (Figure 1). The vertical axis in Figure 1 represents the degree of economic recoverability and the horizontal axis measures the degree of geological certainty. Economically recoverable resources are located in the top left-hand corner of the diagram (e.g. identified proven, probable (established) and possible *reserves*). The feasibility of resource extraction decreases through to the lower right-hand section (e.g. sub-economic and undiscovered *resources*). The boundary between economic and sub-economic resources is affected by the relationship between prices and extraction costs, and technological improvements. The boundary between discovered and undiscovered resources fluctuates as the result of a petroleum company's investment in exploration and development, and differing geological conditions.

Oil and natural gas reserve estimates of Canada provided by the Canadian Petroleum Association (CPA), Alberta Energy Resources Conservation Board (AERCB), National Energy Board and other government agencies are reported as *established* reserves. Established reserves are "those reserves recoverable under current technological and present and anticipated economic conditions, specifically proved by drilling, testing or production, plus that judgement portion of contiguous recoverable reserves that are interpreted to exist from geological, geophysical or similar information, with reasonable certainty" (Tanner, 1986; p. 22).

The AERCB estimates two types of established reserves: *remaining* established reserves and *yet-to-be* established reserves, the sum of which is *remaining ultimate potential* established reserves[1]. Yet-to-be established reserves are based on estimates of future reserve growth from new discoveries and reserve additions to be recov-

1. The term "remaining" refers to initial established reserves less cumulative production.

Figure 1: The McKelvey Box Used to Distinguish Reserves from Resources



Source:
Modified after McKelvey, 1972.

ered from future enhanced recovery. The ultimate potential is defined as an estimate of established reserves that will have been developed in an area by the time all exploratory and development activity has ceased (AERCB, 1991). Estimates of the ultimate potential are used to forecast Alberta's oil supply. Table 1 shows the remaining and yet-to-be established reserves for crude oil and natural gas at the end of 1990.

Table 1: Established Reserves of Crude Oil and Natural Gas in Alberta, 1990

	Remaining established	Yet-to-be established	Remaining ultimate potential	Reserve life
	millions of cubic metres			years
Crude Oil	510	649	1 159	21
Natural Gas	1 649 000	1 420 000	3 114 000	35

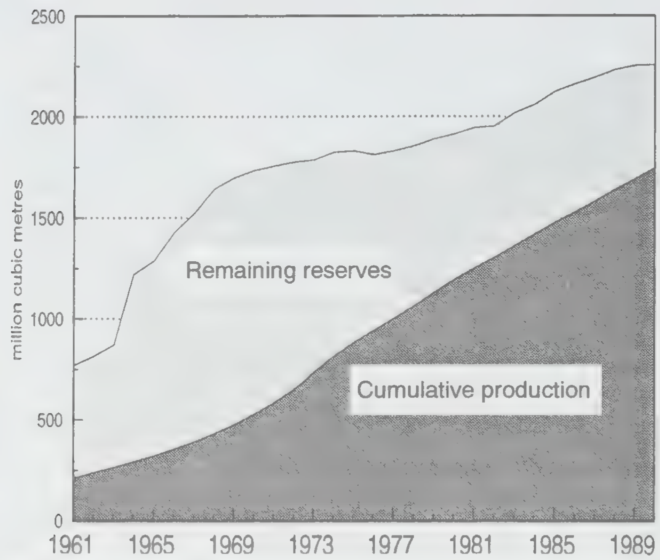
Source:
Alberta Energy Resources Conservation Board, 1991.

This study is concerned with identified economic resources which are defined as those deposits whose location, quality and quantity are known and that can be economically extracted at the time of determination. The physical accounts consist of opening and closing stocks of *remaining established reserves*, extraction (depletion) of reserves and their appreciation as the result of discoveries, development, revisions and enhanced oil recovery (secondary and tertiary recovery) since these reserves have a high probability of being extracted for economic purposes.

In natural resource accounting, both physical and monetary units are needed to provide a complete picture of the use and the stock of natural assets. Physical resource accounts show the total stock of reserves and changes in the stocks, thus providing the stock and flow data required for the monetary balance sheet accounts.

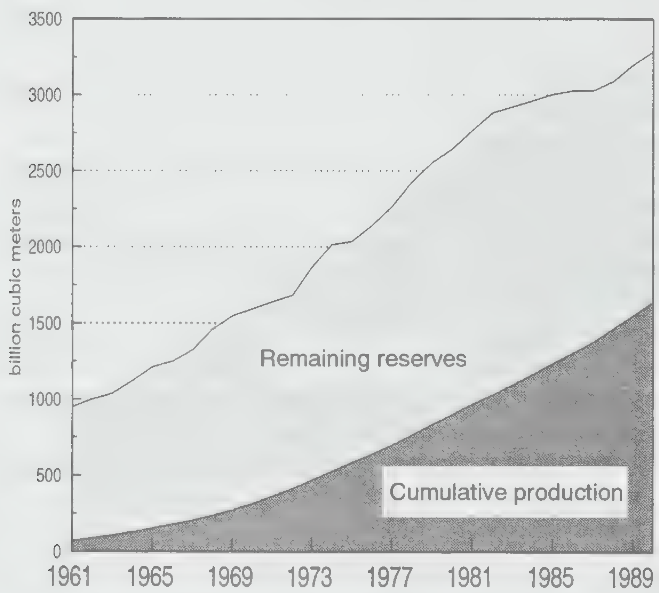
Estimates of remaining established reserves of crude oil and natural gas for the Province of Alberta are provided in Table 5 in the Physical Accounts for the period from 1961 to 1990. Figures 2 and 3 compare the remaining reserves and cumulative production for crude oil and natural gas. For crude oil reserves, the rate of depletion of reserves has remained stable since 1981, averaging 55.2 million cubic metres per year. However, the remaining reserve stock has declined by 27% during that same period. For natural gas reserves, the average depletion rate was 68.3 billion cubic metres from 1978 to 1987 but has increased to an average of 88.2 billion cubic metres for 1988 to 1990. The stock of remaining reserves of natural gas peaked at 1 853 billion cubic metres in 1982 but declined to 1 647 billion cubic metres in 1990. General current trends of reserve stocks indicate that reserve additions are not replacing reserve depletion. This is more prevalent for crude oil than for natural gas.

Figure 2: Summary of Remaining Established Reserves and Cumulative Production of Conventional Crude Oil in Alberta, 1961 - 1990



Sources:
Alberta Energy Resources Conservation Board.
Statistics Canada. National Accounts and Environment Division.

Figure 3: Summary of Remaining Established Reserves and Cumulative Production of Marketable Natural Gas in Alberta, 1961 - 1990



Sources:
Alberta Energy Resources Conservation Board.
Statistics Canada. National Accounts and Environment Division.

THE CONCEPT OF ECONOMIC RENT

The concept of economic rent is central to the monetary valuation of natural resources (Repetto *et al*, 1989). Economic rent constitutes the difference between the international commodity price and all factor costs of extraction, including a normal return to capital but excluding taxes, royalties and other costs that are not part of the cost of physical extraction. The value of the resource in the ground is equal to the future stream of income or economic rent derived from the extraction of the natural resource.

Economic rents obtained from the extraction of petroleum are defined as the returns in excess of those required to sustain production, reserve development and exploration (Kemp, 1992). As owners of the natural resources, governments may collect rents through auctioning of exploration rights, taxation or royalties. With competitive bidding for mineral rights, the host government collects anticipated or *ex ante* economic rents in a lump sum payment. A royalty system is used to ensure that the government receives an acceptable share of the realized or *ex post* economic rents.

Economic rents from natural resources are complex, consisting of Hotelling (scarcity) rents and Ricardian (differential) rents as well as locational rents (arising from differences in transportation costs). Since oil and natural gas reserves are non-renewable and their supply is finite, at least part of the net flow of income can be attributed to the scarcity of the resource. While much of the literature has focused on aggregate economic rent or Hotelling rents, there is little discussion on how to treat these different rents in the context of the development of natural resource accounts. There are conceptual difficulties in separating these resource rents as discussed in Born (1992).

In 1931, Hotelling provided a theoretical model of the behaviour of markets for exhaustible resources. The Hotelling “hypothesis” states that under certainty, in the absence of extraction costs and under competitive market conditions, the price of a natural resource rises at the market rate of interest. The ability of the theory to describe and predict actual behaviour of natural resource markets remains an area of considerable debate with little empirical evidence to support it. However, several recent studies in natural resource accounting of oil and natural gas reserves (Landefeld and Hines, 1985; Repetto *et al*, 1989; and Smith, 1991) use the Hotelling model as the basis for a method of monetary valuation. This is the “net price” approach presented below.

Others (Devarajan and Fisher, 1982, and Lasserre, 1985) have suggested the use of discovery costs plus the rent on exploration prospects (e.g. land acquisition costs) as an approximation for resource rents. The argument is that exhaustible-resource rents can be measured by what firms are ready to spend in exploration and development in order to make the resource available. This is the basis of

the "replacement cost" method of monetary valuation discussed below.

MONETARY VALUATION OF OIL AND NATURAL GAS RESERVES

Mineral deposits should be viewed as capital assets that represent forms of national wealth. Ideally, reserves of mineral resources should be valued at the market prices at which the natural resource asset would be sold. However, most mineral stocks are not traded frequently on the market and their market values must be imputed. Three methods of monetary valuation are proposed in this study:

(i) Present Value
(ii) Net Price
(iii) Replacement Cost

Results from the different methods of valuation are presented for conventional crude oil and natural gas remaining established reserves in Alberta. These results are preliminary and may be further refined before the values are included formally in the Canadian National Balance Sheet Accounts. The three methods produce a wide range of monetary values and the difficulty is to determine what assumptions should be used and which set of estimates is most reliable.

Present Value

As a capital asset, a mineral deposit is valued on the basis of its net flow of income or "rent" that is anticipated over the lifetime of the deposit. If the capital market is competitive and the merit of any investment is assessed in terms of alternative investments, the expected income flow from the deposit is then discounted to establish the "net present value".

The present value approach or discounted value of future net returns has been proposed by the *UN SNA Handbook on Integrated Environment and Economic Accounting* (United Nations, 1990) as the most appropriate method of monetary valuation of opening and closing stocks and changes to stocks due to volumes and price changes. Discounted cash flow analysis is the standard approach used by companies to value properties and is used in annual corporate reports and U.S. Annual reports include the present value of future net cash flows from the estimated production of proven reserves based on the Reserves Recognition Accounting (RRA) method. The RRA method is based on a discounted cash flow or present value which assumes the continuation of current oil and natural gas margins discounted at an arbitrary 10% real rate. A comparison of the results from this study with those from various companies showed similar results (Born, 1992).

The choice of an appropriate discount rate for calculating the present value of reserves is problematic in terms of choosing a "private" or "social" discount rate. There are considerations of intergenerational equity, the opportunity cost of capital and social time preference. Discounting appears to be inconsistent with the concept of sustainable development since the higher the discount rate, the lower the importance attached to the future use of the natural stock (Pearce and Turner, 1990). Adelman (1986) suggests that a nation with a highly diversified portfolio of assets should use a discount rate near the commercial rate employed by industry to discount the flow of net revenues. Long-term corporate bond rates have been used extensively in other studies and are used in this study as the discount rate.

Some of the results from the present value calculations for oil and natural gas are presented in Table 2. Values presented in this report show that in 1990, the value of oil reserves in the ground ranges from $11.9 billion to $14.4 billion and the value of natural gas reserves ranges from $4.1 billion to $7.7 billion, discounted at long-term corporate bond rates. Present value estimates vary considerably depending on the assumptions made and this is their major weakness. Several assumptions relating to the appropriate discount rate, return to man-made capital and depreciation charges need to be chosen in order to produce results.

Net Price

The net price method, as developed by Landefeld and Hines (1985) applies the current average net price per unit (i.e. current revenues less current production costs per unit) to the physical quantities of established reserves. It can be interpreted as an application of the "Hotelling" model where the net price of the resource is expected to rise at exactly at the same rate of return on alternative investments (e.g. the rate of interest). The net price method is a special case of the present value method in which on average, long-run equilibrium is assumed to occur (i.e. the net price will rise at the rate of alternative investments) and the increase in the net price will exactly offset the discount rate.

The net price is calculated from revenues less operating costs less opportunity cost of man-made capital (i.e. the return to capital and depreciation charge) divided by the quantity extracted in a given period. This net price per unit extracted is multiplied by the remaining reserves to obtain the total value of the opening and closing stocks. A variant on this approach, outlined by Landefeld and Hines (1985), subtracts the current replacement cost of man-made capital rather than its opportunity cost.

Table 3 presents preliminary results for the value of reserve of oil and natural gas reserves in Alberta. Two values are shown: the first method subtracts the opportunity cost of man-made capital employed by the petroleum industry plus depreciation and the second method uses the same methodology as Landefeld and Hines (1985). Results from this study indicate that in 1990 the value of crude oil reserves in Alberta ranges from $20.0 billion to $41.2 billion

and the value of natural gas reserves ranges from $10.4 billion to $65.1 billion using the net price approach.

The difference in the estimates from the two methodologies lies in the difference in the treatment of the man-made capital employed in exploring, developing and extracting the natural resource. In the method outlined by Landefeld and Hines (1985), there is no "normal return to (man-made) capital" excluded from the value added of the natural resource.

Most monetary values for oil and natural gas reserves reported in the current literature are based on the net price approach which assumes the Hotelling model. In Alberta, with the collapse of world oil and natural gas prices since 1986 along with increasing extraction costs, the value of resource rents has decreased significantly. Analysis of the data in this study finds that the assumptions of the Hotelling model are too restrictive. It appears that the current net price is not appropriate for valuing future production of reserves. The net price method seems to have undervalued future production during the 1960s and 1970s given the rapid increase in net price from 1972 to 1985 for both oil and natural gas. The net price method has overvalued future production in the early 1980s in light of the wellhead price collapse in 1986. However, the net price provides a basis for comparison with other studies (Repetto *et al*, 1989; and Smith, 1991) and the accounting procedures used in the net price method are similar to those used in the present value method. The net price has an advantage

Table 2: Estimate of the Monetary Value of Crude Oil and Natural Gas Reserves in Alberta Based on the Present Value Method, 1961-1990

Year	Crude oil reserves			Natural gas reserves			Total value of reserves		
	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]
	millions of dollars								
1961	1 927.2	1 461.4	3 417.4	-309.7	-544.6	4 431.8	1 617.5	916.8	7 849.2
1962	1 747.9	1 564.6	2 846.2	110.6	-419.2	5 494.9	1 858.6	1 145.4	8 341.1
1963	2 049.5	1 700.2	3 216.2	930.6	-77.1	6 464.4	2 980.2	1 623.1	9 680.6
1964	2 081.7	1 963.7	3 826.8	1 182.1	378.7	7 333.0	3 263.8	2 342.3	11 159.8
1965	2 297.9	2 341.3	8 343.5	1 359.1	877.6	8 850.7	3 657.0	3 218.8	17 194.2
1966	2 071.2	2 257.4	9 460.0	1 256.5	1 148.5	10 334.9	3 327.8	3 405.9	19 794.9
1967	2 026.6	2 161.2	11 747.7	1 454.6	1 257.1	9 953.2	3 481.2	3 418.3	21 700.9
1968	2 343.1	2 063.3	12 643.4	1 343.5	1 268.5	10 013.8	3 686.6	3 331.8	22 657.2
1969	2 482.7	2 092.5	13430.9	1 056.6	1 230.0	10 429.2	3 539.3	3 322.6	23 860.1
1970	3 639.0	2 478.2	14 777.4	544.9	1 129.6	11 422.8	4 184.0	3 607.7	26 200.2
1971	5 018.6	3 398.9	16 873.1	380.0	996.4	12 568.4	5 398.6	4 395.3	29 441.5
1972	6 543.0	4 405.9	19 989.6	519.0	744.3	15 173.0	7 062.0	5 150.2	35 162.6
1973	10 801.3	6 291.0	25 131.2	1 331.9	747.9	19 724.0	12 133.2	7 038.9	44 855.2
1974	15 839.9	9 012.5	30 800.8	4 489.5	1 667.2	26 321.2	20 329.4	10 679.8	57 122.0
1975	15 394.4	12 313.9	30 412.2	9 892.1	4 145.9	25 839.9	25 286.5	16 459.8	56 252.1
1976	16 039.0	16 032.5	33 237.1	14 587.6	8 199.3	28 556.5	30 626.6	24 231.8	61 793.6
1977	21 037.0	19 639.8	35 206.3	21 206.3	14 146.9	29 984.0	42 243.3	33 786.7	65 190.3
1978	24 834.3	21 609.6	35 965.5	20 924.8	18 407.1	29 595.4	45 759.2	40 016.7	65 560.9
1979	28 646.9	24 196.2	40 686.2	25 882.8	22 296.3	34 833.9	54 529.7	46 492.4	75 520.1
1980	25 160.9	24 995.7	37 957.9	28 699.0	23 982.1	30 375.9	53 859.8	48 977.7	68 333.8
1981	22 013.9	24 178.7	33 676.1	21 155.2	22 398.5	22 826.3	43 169.1	46 577.2	56 502.4
1982	28 642.0	27 481.4	34 828.9	23 683.3	25 640.6	19 152.1	52 325.2	53 122.0	53 981.0
1983	47 051.1	35 846.1	36 610.1	30 644.7	32 469.5	18 467.3	77 695.9	68 315.6	55 077.4
1984	50 967.3	40 552.4	27 955.6	32 226.0	30 483.1	11 818.4	83 193.2	71 035.4	39 774.0
1985	50 620.5	49 074.0	22 891.9	37 082.5	36 008.1	9 966.4	87 702.9	85 082.0	32 858.3
1986	14 083.6	46 847.9	19 173.1	19 789.5	36 012.0	9 023.3	33 873.1	82 859.9	28 196.4
1987	20 838.2	37 988.1	20 368.2	6 788.5	27 817.3	12 752.7	27 626.7	65 805.4	33 120.9
1988	5 958.8	25 002.8	21 178.0	4 160.5	19 195.2	13 377.5	10 119.3	44 198.0	34 555.5
1989	9 218.4	13 358.7	21 958.4	2 491.9	9 420.2	15 225.2	11 710.3	22 778.9	37 183.6
1990	11 931.4	12 033.5	14 406.5	4 142.2	4 593.4	7 705.2	16 073.6	16 627.0	22 111.7

Notes:
[1] Discounted using a long-term bond corporate bond rate; based on year-end prices and costs.
[2] Same as [1] except based on a 4-year moving average.
[3] Based on "perfect knowledge" of production, prices and costs; discounted using a long-term corporate bond rate.
The results in this table should be treated as preliminary.

over present value calculations since there is no need to forecast or to make assumptions about future prices, extraction costs and rates, and interest rates.

Replacement Cost

Conceptually, resource rent is the most appropriate measure of the value of the resource in the ground. However, there are some problems involved when resource rents are used since rental values are not readily observed and must be imputed. Several studies have used the cost of discovering and developing reserves as a proxy for resource rent. The argument is that exploration and development dollars will be spent as long as the expected gain from finding the resource equals the marginal cost of exploration and development. The expected discovery value of the resource stock should be equal to the present value of its expected rents.

In this study the "full marginal discovery cost" approach developed by Eglington and Uffelmann (1983), Lasserre (1985) and McLachlan (1990) has been adopted to approximate resource rent. It is the sum of the marginal cost of exploration and development plus land acquisition costs divided by reserve additions in a given period (e.g. reserves from discoveries, development and revisions, and in the case of crude oil reserves, enhanced oil recovery) to yield a replacement cost per unit of crude oil or natural gas reserve added. A 5-year average is used to average the costs and the booked reserve additions. The average unit cost of booked reserves is multiplied by the remaining es-

Table 3: Estimates of the Monetary Value of Crude Oil and Natural Gas Reserves in Alberta Based on the Net Price Method, 1961-1990

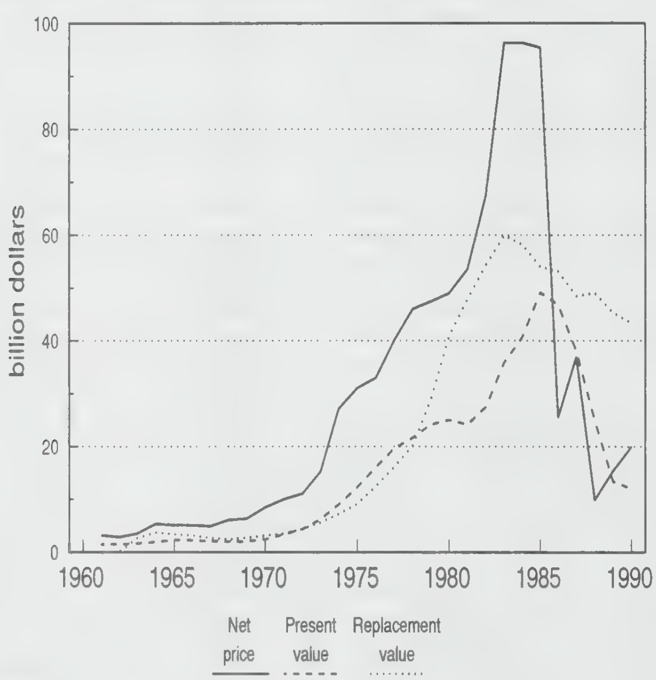
Year	Crude oil reserves		Natural gas reserves		Total value of reserves	
	[1]	[2]	[1]	[2]	[1]	[2]
	millions of dollars					
1961	3 189.1	5 279.7	-1 279.8	1 896.2	1 909.3	7 175.9
1962	2 896.6	5 121.3	335.7	2 783.2	3 232.3	7 904.5
1963	3 519.4	6 047.8	2 582.9	5 052.8	6 102.2	11 100.6
1964	5 384.0	10 188.4	3 258.2	5 877.8	8 642.2	16 066.2
1965	5 106.6	10 489.5	3 759.8	6 660.2	8 866.4	17 149.7
1966	5 145.1	11 633.1	3 703.0	7 132.0	8 848.2	18 765.0
1967	4 920.8	11 569.7	4 508.7	8 543.5	9 429.4	20 113.3
1968	6 154.9	13 280.6	4 608.4	9 560.2	10 763.3	22 840.8
1969	6 431.2	13 572.2	3 335.3	8 322.1	9 766.5	21 894.3
1970	8 510.3	14 730.0	1 700.6	7 567.3	10 210.8	22 297.3
1971	10 061.3	15 674.3	949.5	6 522.5	11 013.4	22 196.8
1972	11 094.0	15 411.8	1 218.0	6 967.6	12 312.0	22 379.4
1973	15 261.6	18 327.5	3 343.0	10 383.1	18 604.6	287 10.5
1974	27 161.3	31 408.5	13 130.9	23 953.7	40 292.2	55 362.2
1975	31 061.9	36 934.0	29 282.7	43 114.4	60 344.6	80 048.4
1976	32 959.5	39 137.6	45 249.7	63 037.7	78 209.2	102 175.2
1977	40 072.5	45 945.0	58 962.7	77 638.3	99 035.2	123 583.2
1978	45 944.0	52 143.1	59 089.6	81 672.9	105 033.6	133 816.0
1979	47 405.9	53 165.4	75 827.3	104 952.4	123 233.2	158 117.8
1980	48 936.2	57 747.7	108 121.9	158 274.1	157 058.1	216 021.9
1981	5 3520.6	68 341.5	92 319.5	162 327.4	145 840.1	230 668.9
1982	67 414.7	84 503.8	115 804.9	211 901.2	183 219.6	296 405.0
1983	96 300.4	111 590.3	111 886.2	187 556.8	208 186.6	299 147.0
1984	96 258.0	111 990.5	118 565.9	194 992.3	214 823.8	306 982.8
1985	95 353.3	113 337.7	113 027.7	179 398.8	208 380.9	292 736.6
1986	25 440.0	43 965.9	54 618.4	116 868.3	80 058.4	160 834.2
1987	37 004.5	56 728.0	19 029.6	82 871.6	56 034.1	139 599.6
1988	9 856.3	28 558.4	9 766.6	56 817.6	19 622.8	85 375.9
1989	15 438.4	35 650.5	6 041.1	57 122.9	21 479.5	92 773.4
1990	19 962.9	41 244.9	10 368.5	65 081.1	30 335.3	106 326.0

Notes:
[1] Net price equals revenue less operating costs, return on capital and depreciation charge.
[2] Net price is based on the methodology by Landefeld and Hines (1985).
The results in this table should be treated as preliminary.

tablished reserves of crude oil and natural gas to obtain the value of the stock.

Table 4 presents a summary of the estimates of the replacement cost value of crude oil and natural gas reserves. The replacement value for crude oil has declined from $60 billion to $43 billion over the 1983 to 1990 period. While replacement costs for reserve additions per unit have increased, the volume of remaining reserves has decreased by 22% over the period, thus accounting for the trend in the value of remaining oil reserve stock. The replacement cost value which represents the present value of obtaining reserve additions through exploration and development produces similar results to the present value method until 1987 (Figure 4).[1] This suggests that the expected discovery value of the resource stock is equal to the present value of its expected rents. The oil price collapse in 1986 and increasing capital costs have caused a significant decrease in the present value of oil reserves since 1986. It appears since 1986 that the assumption that the full marginal discovery cost can be used as a proxy for resource rent no longer applies in the short term.

Figure 4: Estimates of the Monetary Value of Crude Oil Reserves in Alberta, 1961-1990



Note:
The net price is from [1] in Table 3 and the present value is from [2] in Table 2.

1. Both the replacement cost value and the present value are "discounted" using a long-term corporate bond yield.

The replacement cost value for natural gas reserves shows an increase from $53 billion in 1982 to $81 billion in 1990. While physical reserve stocks have decreased by 12% from 1982 to 1990, replacement costs per unit of reserve added have more than doubled, thus producing increasing values for the total stock of natural gas. Present value and replacement cost value have similar trends until 1979 after which the replacement cost value increases and the present value decreases (Figure 5).

Table 4: Estimates of the Economic Value of Crude Oil and Natural Gas Reserves in Alberta Based on the Replacement Cost Method

Year	Crude oil reserves: Unit cost	Crude oil reserves: Value	Natural gas reserves: Unit cost	Natural gas reserves: Value	Total reserve value
	dollars per m^3	millions of dollars	dollars per thousand m^3	millions of dollars	millions of dollars
1963	4.35	2 632.5	1.86	1 728.6	4 361.1
1964	3.99	3 700.4	2.04	2 020.7	5 721.0
1965	3.50	3 384.6	2.28	2 412.6	5 797.2
1966	2.96	3 179.3	2.37	2 546.2	5 725.5
1967	2.41	2 734.6	2.77	3 101.6	5 836.2
1968	2.04	2 469.7	3.02	3 690.8	6 160.6
1969	2.30	2 810.5	3.37	4 296.3	7 106.8
1970	2.58	3 122.0	3.96	5 066.6	8 188.6
1971	3.02	3 547.3	4.69	5 984.8	9 532.1
1972	3.92	4 409.9	5.13	6 507.7	10 917.5
1973	5.38	5 655.9	5.63	7 860.1	13 516.0
1974	7.20	7 278.7	6.60	9 806.7	17 085.4
1975	9.66	9 183.1	7.30	10 593.9	19 777.0
1976	14.29	12 452.1	8.03	12 063.3	24 515.5
1977	19.40	16 098.3	8.65	13 570.4	29 668.7
1978	25.35	20 138.0	10.23	17 038.9	37 176.9
1979	37:99	28 877.1	13.08	22 472.3	51 349.4
1980	56.73	40 841.6	17.67	30 871.4	71 713.1
1981	68.74	47 842.8	22.88	41 082.8	88 925.7
1982	83.59	54 285.4	28.76	53 295.5	107 580.9
1983	91.04	59 886.8	31.92	58 292.1	118 178.9
1984	90.75	58 145.4	32.46	58 378.1	116 523.5
1985	83.21	53 960.1	31.35	55 428.3	109 388.4
1986	83.71	53 131.4	30.68	52 778.0	105 909.4
1987	78.89	48 424.2	35.11	57 988.6	106 412.8
1988	82.67	49 013.4	41.60	67 718.3	116 731.6
1989	80.71	45 235.6	46.10	76 050.7	121 286.4
1990	84.95	43 359.4	49.41	81 406.1	124 765.6

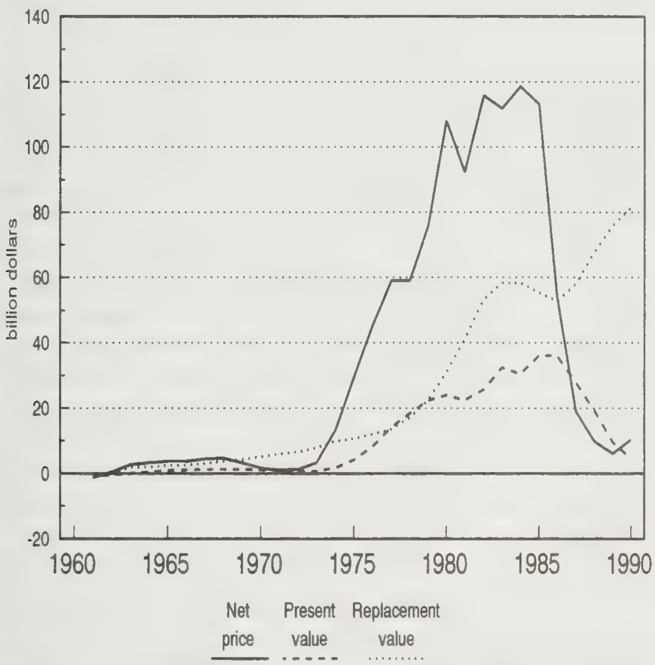
Notes:
The results in this table should be treated as preliminary.
Includes all exploration and development expenditures and land bonuses; data are time-lagged and unit costs are derived from a 5-year average of booked reserve additions; unit costs are averaged over 5 years.

It appears that the replacement cost method measures resource scarcity. It is not, however, a proxy for the measurement of the value of natural resource wealth which accounts for capital gains and losses due to price changes over time.

Comparison of Valuation Methods

Figures 4 and 5 provide a comparison of the estimates from the three different valuation methods described above. As previously discussed, present values and replacement cost values show similar trends until 1986. The net price estimates initially overvalue the reserve stock in the late 1980s given the price collapse of 1986 however they show a similar trend to present value after 1986.

Figure 5: Estimates of the Monetary Value of Natural Gas Reserves in Alberta, 1961-1990



Note:
The net price is from [1] in Table 3 and the present value is from [2] in Table 2.

In comparison with the net price approach, the present value approach provides a smoother times series since the method reduces price volatility by averaging or using actual wellhead price in cases [2] and [3] in Table 2, using interest rates related to the time period rather than assuming a constant discount rate such as 10% for the entire 30-year time span and averaging or using actual variable (extraction) costs in calculations [2] and [3] in Table 2.

The advantages and disadvantages of each method have been discussed. However, with the net price method, the assumption of long-run equilibrium in natural resource markets has little empirical support and produces volatile values. The selection of the most appropriate valuation method for the Canadian National Balance Sheet will reflect the most reliable method of market valuation. The present value method conforms most closely to corporate financial reporting of the market value of reserves and is the preferred method of valuation by national accountants. However assumptions about future prices, costs and discounts have to be made when using this method.

RECONCILIATION ACCOUNTS

Table 5 presents both physical and monetary Reconciliation Accounts for oil and natural gas reserves from 1961 to 1990. Net price values from Table 3 [1] for oil and natural gas are used to construct the monetary accounts in Table 5.

Reconciliation tables show the volume and price changes of the assets during the reporting period, in this case, one year. The basic formula for the reconciliation accounts is:

closing stock = opening stock + net reserve additions - reserve depletion + revaluation

where revaluation reflects the change in net price during periods in the monetary accounts only.

The monetary reconciliation accounts reflect changes in the net value of the resource due to changes in physical reserves, wellhead prices and operating and capital costs. These changes will be reflected in the value of non-produced tangible assets in the Balance Sheet Accounts and ultimately in national wealth and net worth.

Table 5: Reconciliation Tables for Established Reserves of Crude Oil and Natural Gas in Alberta, 1961-1975

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
CRUDE OIL RESERVES															
Physical accounts (millions of cubic metres)															
Opening stocks	525.0	557.6	575.6	605.4	926.1	965.7	1 074.2	1 132.9	1 212.8	1 222.8	1 207.9	1 173.6	1 126.0	1 052.0	1 011.5
Gross additions	57.5	44.0	56.6	348.5	68.8	140.8	95.2	119.8	54.5	36.7	22.1	20.0	9.2	38.5	7.0
Discoveries	1.7	2.9	14.6	9.5	28.6	89.1	57.2	62.0	40.5	8.4	14.0	10.8	5.1	4.3	1.6
Development and reevaluation	31.5	21.8	12.6	88.2	42.6	13.5	15.7	14.8	-44.5	-7.6	8.7	-5.6	-6.0	3.3	2.1
Enhanced oil recovery	24.5	19.9	29.2	250.8	-2.4	38.3	22.2	42.9	58.5	36.1	-0.8	14.8	10.2	30.8	3.3
Depletion	25.1	26.2	26.8	27.9	29.2	32.2	36.6	39.8	44.4	51.7	56.4	67.4	83.3	79.0	67.5
Net change	32.4	17.8	29.8	320.6	39.6	108.6	58.6	80.0	10.1	-15.0	-34.3	-47.4	-74.1	-40.5	-60.5
Closing stock	557.6	575.6	605.4	926.1	965.7	1 074.2	1 132.9	1 212.8	1 222.8	1 207.9	1 173.6	1 126.0	1 052.0	1 011.5	950.9
Unit values (dollars per cubic metre)															
Average wellhead price	14.82	14.28	15.81	16.09	16.14	16.27	16.06	16.14	16.00	16.27	17.84	17.92	21.83	36.33	45.79
Production and capital costs	9.10	9.24	10.00	10.28	10.85	11.49	11.72	11.06	10.74	9.23	9.27	8.07	7.32	9.48	13.12
Net price	5.72	5.03	5.81	5.81	5.29	4.79	4.34	5.07	5.26	7.05	8.57	9.85	14.51	26.85	32.67
Monetary accounts (millions of dollars)															
Opening stocks	2 106	3 189	2 897	3 519	5381	5 107	5 145	4 921	6 155	6 431	8 510	10 061	11 094	15 262	27 078
Gross additions	329	221	329	2025	364	674	414	608	287	259	189	197	133	1034	229
Discoveries	10	15	85	55	151	427	248	314	213	59	120	106	74	115	52
Development and reevaluation	180	110	73	513	225	65	68	75	-234	-54	75	-55	-87	48	69
Enhanced oil recovery	140	100	170	1458	-13	183	96	218	308	255	-7	146	148	447	108
Depletion	144	132	156	162	154	153	159	202	234	364	483	664	1 209	1 146	2 205
Net change	185	90	173	1 863	209	521	255	406	53	-106	-294	-467	-1 075	-112	-1 977
Revaluation	896	-383	450	-2	-484	-481	-479	829	224	2 184	1 845	1 502	5 241	12 987	5 887
Closing stock	3 189	2 897	3 519	5381	5 107	5 145	4 921	6 155	6 431	8 510	10 061	11 094	15 262	27 161	31 062
NATURAL GAS RESERVES															
Physical accounts (billions of cubic metres)															
Opening stocks	878.6	879.9	912.1	928.2	992.0	1 057.6	1 072.6	1 119.1	1 223.6	1 273.4	1 279.4	1 276.3	1 269.1	1 396.6	1 486.5
Gross additions	13.3	49.7	35.8	85.9	89.7	40.6	73.9	134.6	87.5	46.2	45.4	45.2	183.3	147.0	20.8
Discoveries	9.6	8.9	3.1	7.2	11.3	2.1	24.3	15.3	18.6	7.6	4.8	12.5	7.8	8.6	0.8
Development and reevaluation	3.7	41.0	32.7	78.7	78.4	38.6	49.6	119.3	68.9	38.7	40.6	32.8	175.6	138.4	20.0
Depletion	11.9	17.6	19.6	22.1	24.2	25.5	27.5	30.0	37.8	40.1	48.5	52.4	56.0	57.0	56.6
Net change	1.4	32.1	16.2	63.8	65.5	15.2	46.4	104.6	49.7	6.2	-3.1	-7.1	127.4	90.0	-35.8
Closing stock	879.9	912.1	928.2	992.0	1 057.6	1 072.6	1 119.1	1 223.6	1 273.4	1 279.4	1 276.3	1 269.1	1 396.6	1 486.5	1 450.8
Unit values (dollars per thousand cubic metres)															
Average composite wellhead price	6.08	6.62	8.53	9.14	9.59	10.64	11.80	12.34	10.48	10.75	9.87	11.01	13.25	23.46	38.93
Production and capital costs	7.53	6.26	5.75	5.86	6.03	7.19	7.77	8.58	7.86	9.42	9.12	10.05	10.86	14.63	18.74
Net price	-1.45	0.37	2.78	3.28	3.56	3.45	4.03	3.77	2.62	1.33	0.74	0.96	2.39	8.83	20.18
Monetary accounts (millions of dollars)															
Opening stocks	-2 443	-1 280	336	2 583	3 258	3 760	3 703	4 509	4 608	3 335	1 701	949	1 218	3 343	13 126
Gross additions	-19	18	100	282	319	140	298	507	229	61	34	43	439	1299	420
Discoveries	-14	3	9	24	40	7	98	58	49	10	4	12	19	76	16
Development and reevaluation	-5	15	91	258	279	133	200	449	180	51	30	31	420	1 222	406
Depletion	-17	7	54	73	86	88	111	113	99	53	36	50	134	503	1 142
Net change	-2	12	45	210	233	52	187	394	130	8	-2	-7	305	795	-723
Revaluation	1 167	1 604	2 202	466	268	-109	618	-294	-1 404	-1 643	-749	275	1 820	8 994	16 872
Closing stock	-1 280	336	2 583	3 258	3 760	3 703	4 509	4 608	3 335	1 701	949	1 218	3 343	13 131	29 283

Note:
Discrepancies are due to rounding and data sources.
Sources:
Alberta Energy Resources Conservation Board.
Statistics Canada, National Accounts and Environment Division.

Table 5: Reconciliation Tables for Established Reserves of Crude Oil and Natural Gas in Alberta, 1976-1990

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
CRUDE OIL RESERVES															
Physical accounts (millions of cubic metres)															
Opening stocks	950.9	871.3	830.0	794.5	760.2	719.9	696.0	649.4	657.8	640.7	648.5	634.7	613.8	592.9	560.5
Gross additions	-18.6	19.1	24.4	34.3	22.7	32.6	6.9	64.1	42.0	64.0	39.1	33.0	36.7	21.4	3.0
Discoveries	2.5	4.8	24.9	19.2	9.0	15.0	16.8	21.4	29.1	32.7	28.6	20.9	17.7	17.0	25.0
Development and reevaluation	5.9	5.1	-1.9	10.3	5.1	10.4	-16.5	24.8	-12.0	9.7	-14.1	1.6	2.5	-3.4	-25.6
Enhanced oil recovery	-27.0	9.2	1.4	4.8	8.6	7.2	6.6	17.9	24.1	21.6	24.6	10.5	16.5	7.8	3.7
Depletion	61.0	60.4	60.0	68.5	63.2	56.5	53.6	55.0	59.2	56.2	53.2	53.9	57.2	53.8	53.1
Net change	-79.6	-41.3	-35.6	-34.2	-40.5	-23.9	-46.7	8.5	-17.2	7.8	-14.1	-20.9	-20.5	-32.4	-50.1
Closing stock	871.3	830.0	794.5	760.2	719.9	696.0	649.4	657.8	640.7	648.5	634.7	613.8	592.9	560.5	510.5
Unit values (dollars per cubic metre)															
Average wellhead price	53.73	64.40	76.77	82.97	97.75	119.36	157.64	201.29	212.44	220.07	117.58	145.35	104.92	127.74	150.69
Production and capital costs	15.90	16.11	18.94	20.61	29.77	42.47	53.83	54.90	62.20	73.03	77.50	85.06	88.30	100.20	111.58
Net price	37.83	48.28	57.83	62.36	67.98	76.90	103.81	146.40	150.24	147.04	40.08	60.29	16.62	27.54	39.11
Monetary accounts (millions of dollars)															
Opening stocks	31 062	32 960	40 073	45 944	47 406	48 936	53 521	67 415	96 300	96 258	95 353	25 440	37 004	9 856	15 438
Gross additions	-704	922	1 411	2 139	1 543	2 507	716	9 384	6 310	9 410	1 567	1 989	610	589	117
Discoveries	95	232	1 440	1 197	612	1 154	1 744	3 133	4 372	4 808	1 146	1 260	294	468	978
Development and reevaluation	223	246	-110	642	353	554	-1 713	3 631	-1 803	1 426	-565	96	42	-94	-1 001
Enhanced oil recovery	-1 021	444	81	299	585	800	685	2 621	3 621	3 176	986	633	274	215	145
Depletion	2 308	2 916	3 470	4 272	4 296	4 345	5 564	8140	8 894	8 264	2 132	3 250	951	1 482	2 077
Net change	-3 011	-1 994	-2 059	-2 133	-2 753	-1 838	-4 848	1 244	-2 584	1 147	-565	-1 260	-341	-892	-1 959
Revaluation	4 909	9 107	7 924	3 601	4 270	6 422	18 732	27 656	2 527	-2 052	-69 360	12 824	-26 801	6 474	6 484
Closing stock	32 960	40 073	45 944	47 406	48 936	53 521	6 715	96 300	96 258	95 353	25 440	37 004	9 856	15 438	19 963
NATURAL GAS RESERVES															
Physical accounts (billions of cubic metres)															
Opening stocks	1 450.8	1 501.7	1 568.3	1 665.2	1 718.4	1 747.0	1 795.3	1 853.1	1 826.2	1 798.4	1 768.3	1 720.1	1 651.7	1 627.7	1 649.7
Gross additions	105.6	127.6	163.3	123.2	92.4	117.0	118.7	39.0	40.5	42.6	21.8	0.0	64.6	107.8	87.8
Discoveries	6.9	6.6	24.4	16.4	30.0	28.9	10.6	16.3	9.6	11.5	9.2	8.9	13.9	19.0	28.0
Development and reevaluation	98.7	120.9	138.9	106.8	62.5	88.1	108.1	22.7	30.9	31.1	12.6	-8.9	50.7	88.8	60.0
Depletion	54.6	61.0	66.4	70.0	63.8	68.6	60.9	66.0	68.3	72.8	69.9	68.4	88.6	85.8	90.1
Net change	51.0	66.5	96.9	53.2	28.7	48.4	57.8	-27.0	-27.8	-30.2	-48.1	-68.4	-24.0	22.0	-2.3
Closing stock	1 501.7	1 568.3	1 665.2	1 718.4	1 747.0	1 795.3	1 853.1	1 826.2	1 798.4	1 768.3	1 720.1	1 651.7	1 627.7	1 649.7	1 647.4
Unit values (dollars per thousand cubic metres)															
Average composite wellhead price	54.88	64.38	66.73	80.98	117.66	117.57	146.86	135.55	144.62	139.24	107.13	92.35	74.12	76.82	81.59
Production and capital costs	24.75	26.78	31.25	36.85	55.77	66.14	84.37	74.28	78.69	75.32	75.38	80.83	68.12	73.16	75.29
Net price	30.13	37.60	35.48	44.13	61.89	51.42	62.49	61.27	65.93	63.92	31.75	11.52	6.00	3.66	6.29
Monetary accounts (millions of dollars)															
Opening stocks	29 283	45 250	58 963	59 090	75 827	10 8122	92 319	115 805	111 886	118 566	113 028	54 618	19 030	9 767	6 041
Gross additions	3 182	4 797	5 795	5 436	5 719	6 016	7 418	2 389	2 670	2 723	692	0	388	395	553
Discoveries	208	248	866	724	1 857	1 486	662	999	633	735	292	103	83	70	176
Development and reevaluation	2 974	4 546	4 928	4 713	3 868	4 530	6 755	1 391	2 037	1 988	400	-103	304	325	376
Depletion	1 645	2 294	2 356	3 089	3955	3 527	3 806	4 044	4 503	4 653	2 220	788	532	314	567
Net change	1 537	2504	3439	2347	1764	2 489	3 612	-1 654	-1 833	-1 930	-1 527	-788	-144	81	-14
Revaluation	14 433	11 209	-3 312	14 390	30 525	-18 286	19 873	-2 271	8 513	-3 614	-56 879	-34 801	-9 119	-3 806	4 342
Closing stock	45 250	58 963	59 090	7 5827	108 122	92 319	115 805	111 886	118 566	113 028	54 618	19 030	9 767	6 041	10 368

Note:
Discrepancies are due to rounding and data sources.
Sources:
Alberta Energy Resources Conservation Board.
Statistics Canada, National Accounts and Environment Division.

Table 6: Value of Petroleum Royalties and Land Costs Paid to the Alberta Government, 1961-1990

Year	Royalties	Land costs	Total
	millions of dollars		
1961	55.0	85.4	140.4
1962	66.0	81.8	147.8
1963	73.0	89.8	162.8
1964	80.0	131.8	211.8
1965	79.2	193.7	272.8
1966	91.7	171.2	262.9
1967	107.4	161.2	269.0
1968	125.6	166.2	291.7
1969	136.3	181.1	317.3
1970	154.0	117.6	271.6
1971	190.4	126.2	316.6
1972	226.0	125.6	351.6
1973	422.6	145.4	568.0
1974	1 107.2	158.6	1 265.8
1975	1 477.7	209.9	1 687.6
1976	2 087.6	256.0	2 343.6
1977	2 398.9	682.1	3 080.9
1978	3 054.9	749.3	3 804.2
1979	3 623.3	1 153.0	4 776.3
1980	3 920.3	1 229.6	5 149.9
1981	4 496.7	736.1	5 232.8
1982	5 098.1	465.6	5 563.7
1983	5 467.2	565.1	6 032.3
1984	5 958.1	790.3	6 748.3
1985	5 843.3	1 021.1	6 864.4
1986	3 205.0	447.3	3 652.3
1987	2 634.7	841.1	3 475.8
1988	2 456.9	676.5	3 133.4
1989	2 559.0	551.7	3 110.7
1990	3 085.0	614.2	3 699.2

Source:
Statistics Canada, *The Crude Petroleum and Natural Gas Industry*, Catalogue 26-213 (various years).

Table 6 provides the value of royalties and land costs paid to the Alberta government from 1961 to 1990. The data demonstrate that the extraction of oil and natural gas generates significant amounts of revenue to the Alberta government. As suggested earlier, land costs represent an *ex ante* rent and royalties are *ex post*. With the decline in the value of rent from oil and gas reserves due to declining reserve stocks and prices, and increasing operating and capital costs, one can observe how potential income to government could also decrease.

SUMMARY

This study has examined the treatment of a non-renewable resource, oil and natural gas reserves in Alberta, in the national accounts. Natural resources have long been regarded as free gifts of nature by economists. The assumption that our natural resources are in infinite supply with a zero supply price is being reconsidered in national accounting. Since balance sheets measure national wealth, Canada's wealth is currently not being estimated correctly by including only man-made assets and excluding non-renewable and renewable resource stocks.

Physical accounts are necessary in order to describe the interrelationship between the environment and the economy. These accounts not only show the short-term exploitation of natural resources but also show the remaining stocks available for primary inputs to economic activity. The physical quantities are required in order to determine the monetary value of the remaining stock.

The focus of this study has been to determine an appropriate method of natural resource valuation. While the development of the physical accounts is based on the definition of established reserves, the monetary accounts require further evaluation in order to incorporate monetary values into the Canadian National Balance Sheet. The present value and the net price approaches seem to conform most closely to the development of wealth accounts. These approaches allow the value of man-made capital employed by the industry to be separated from the value of natural resource itself and identify capital gains and losses due to price changes. This is not the case for the replacement cost approach. While the present value approach is favoured by national accountants, in general and is used in corporate financial reporting, it is limited by the assumptions required.

Oil and natural gas reserves are assets and are components of the national wealth. By extending the definition of capital to cover both man-made and natural capital, a balance sheet presentation shows to what extent natural resource depletion is offset by the addition of man-made and natural capital. If future income and consumption are based on the level of capital stocks, it is important to include the value of the stock of natural resources as well as the value of the man-made capital in the Canadian National Balance Sheet Accounts in order to show whether or not we have sustainable growth and development.

By including the value of natural resources as a non-produced asset and the value of man-made capital in the Canadian Balance Sheet Accounts, one has a more complete picture of Canada's wealth. One can determine whether or not we are creating wealth while depleting our natural resource base or consuming the revenue generated from natural resource extraction. Incorporating the value of oil and natural gas reserve stocks into the Balance Sheet Accounts will be the next stage of this project.

REFERENCES

Adelman, M.A. "Oil Producing Countries' Discount Rates". *Resources and Energy,* vol. 8, 1986. p. 309-329.

Alberta Energy Resources Conservation Board. "Alberta's Reserves of Crude Oil, Oil Sands, Gas, Natural Gas Liquids and Sulphur". *ERCB ST91-18,* 1991.

Bartelmus, Peter. "Environment Statistics and Accounting". 48th ISI Session, Cairo Sept. 9-17, 1991.

Bartelmus, P. *et al.* Integrated Environmental and Economic Accounting: Framework for a SNA Satellite System; *Review of Income and Wealth,* ser. 37, no. 2, 1991 p. 111-148.

Born, Alice. "Development of Natural Resource Accounts: Physical and Monetary Accounts for Crude Oil and Natural Gas Reserves in Alberta, Canada". *Discussion Paper No. 12,* National Accounts and Environment Division, Statistics Canada, 1991.

Canadian Petroleum Association. *Statistical Yearbook* (various years).

Devarajan, S. and Fisher, A. "Exploration and Scarcity". *Journal of Political Economy,* vol. 90, no.6, 1982. p. 1279-1290.

Eglington, P. and Uffelmann, M. 'Observed Costs of Oil and Gas Reserves in Alberta, 1957-1979". *Discussion Paper No. 235,* Ottawa, Ontario: Economic Council of Canada. 1983.

Hotelling, H. "The Economics of Exhaustible Resources". *Journal of Political Economy,* vol. 39, 1931. p. 137-175.

Kemp, A., "Petroleum Policy Issues in Developing Countries". *Energy Policy,* Feb. 1992, p. 104-115.

Landefeld, J.S. and Hines, J.R. "National Accounting for Non-renewable Natural Resources in the Mining Industries". *Review of Income and Wealth*, vol. 31, 1985. p. 1-20.

Lasserre, P. "Discovery Costs as a Measurement of Rent". *Canadian Journal of Economics*, vol. 18, 1985. p. 474-483.

Levin, J. "Valuation and Treatment of Depletable Resources in the National Accounts". *IMF Working Paper 58*, International Monetary Fund, 1991.

McKelvey, V.E. Mineral Resource Estimates and Public Policy". *American Scientist*, vol. 60, 1972. p. 32-40.

McLachlan, M. "Replacement Costs for Oil and Gas in Western Canada: Methodologies and Application". *CERI Research Report 90-1,* Calgary, Alberta: Canadian Energy Research Institute, 1990.

Pearce, D.W. and Turner, R.K., *Economics of Natural Resources and the Environment*. Baltimore: The John Hopkins University Press, 1990.

Repetto, R. *et al.* "Wasting Assets: Natural Resources in the National Accounts". Washington: World Resources Institute, 1989.

Smith, R.S. "Income Growth, Government Spending and Wasting Assets - Alberta's Oil and Gas". Unpublished Manuscript, University of Alberta, Edmonton, Alberta, 1991.

Statistics Canada. *Exploration and Development and Capital Expenditures from Mining and Petroleum and Natural Gas Wells*, Catalogue 61-216 (various years).

----. *The Crude Petroleum and Natural Gas Industry.* Catalogue 26-213 (various years).

Tanner, J.N. "Reserves of Hydrocarbons in Alberta: A Review of Canadian Petroleum Association and Alberta Energy Resources Conservation Board Estimates and Methodology". *CERI Research Report 86-2,* Calgary, Alberta: Canadian Energy Research Institute, 1986.

United Nations. *SNA Handbook on Integrated Environmental and Economic Accounting: Preliminary Draft of the Part 1: General Concepts.* New York, 1989.

van Tongeren, J. *et al.* "Integrated and Economic Accounting: A Case Study for Mexico". *Environment Working Paper No. 50*, The World Bank, Environment Department, 1991.

ORDER FORM

Statistics Canada Publications

MAIL TO:	METHOD OF PAYMENT
Publication Sales **Statistics Canada** **Ottawa, Ontario, K1A 0T6**	☐ Purchase Order Number *(please enclose)* ______
FAX TO: (613) 951-1584 This fax will be treated as an original order. Please do not send confirmation.	☐ Payment enclosed $ ______
(Please print)	**Charge to my:** ☐ MasterCard ☐ VISA
Company ______	Account Number ______
Department ______	Expiry Date ______
Attention ______	Signature ______
Address ______	Client Reference Number ______
City ______ Province ______	
Postal Code ______ Tel. ______	

Catalogue Number	Title	Required Issue	Annual Subscription or Book Price			Qty	Total $
			Canada $	United States US$	Other Countries US$		
11-509E	Human Activity and the Environment, 1991	Occasional 09/91	35.00	42.00	49.00		
11-526	Households and the Environment, 1991	Occasional 07/92	23.95	28.95	33.95		
11-527E	Databases for Environmental Analysis: Government of Canada	Occasional 12/92	55.00	66.00	77.00		
11-528E	Environmental Perspectives 1993: Studies and Statistics	Occasional 03/93	25.00	30.00	35.00		

	SUBTOTAL	
Canadian customers add 7% Goods and Services Tax.	**GST (7%)**	
Please note that discounts are applied to the price of the publication and not to the total amount which might include special shipping and handling charges and the GST.	**GRAND TOTAL**	

Cheque or money order should be made payable to the Receiver General for Canada/Publications. Canadian clients pay in Canadian funds. Clients from the United States and other countries pay total amount in US funds drawn on a US bank.

For faster service **1-800-267-6677** **VISA and MasterCard Accounts**

PF
092146
1993-03

Version française de ce bon de commande disponible sur demande

BON DE COMMANDE

Publications de Statistique Canada

POSTEZ À :
Vente des publications
Statistique Canada
Ottawa (Ontario) K1A 0T6

TÉLÉCOPIEZ À : (613) 951-1584

Le bon télécopié tient lieu de commande originale. Veuillez ne pas envoyer de confirmation.

(En caractères d'imprimerie s.v.p.)

Entreprise ______________________

Service ______________________

À l'attention de ______________________

Adresse ______________________

Ville ______________ Province ______________

Code postal ______________ Tél. ______________

MODALITÉS DE PAIEMENT

☐ Numéro d'ordre d'achat *(inclure s.v.p.)* ______________

☐ Paiement inclus ______________ $

Portez à mon compte : ☐ MasterCard ☐ VISA

Nº de compte ______________

Date d'expiration ______________

Signature ______________________

Numéro de référence du client ______________________

Numéro au catalogue	Titre	Édition demandée	Abonnement annuel ou prix de la publication			Qté	Total $
			Canada $	États-Unis $ US	Autres Pays $ US		
11-509F	Activité humaine et l'environnement, 1991	Hors série 09/91	35,00	42,00	49,00		
11-526	Les ménages et l'environnement, 1991	Hors série 07/92	23,95	28,95	33,95		
11-527F	Bases de données pour l'analyse environnementale: gouvernementale du Canada	Hors série 12/92	55,00	66,00	77,00		
11-528F	Perspectives sur l'environnement 1993: Études et statistiques	Hors série 03/93	25,00	30,00	35,00		

	TOTAL	
Les clients canadiens ajoutent la taxe de 7 % sur les produits et services.	**TPS (7 %)**	
Veuillez noter que les réductions s'appliquent au prix des publications et non au total général; ce dernier pouvant inclure des frais de port et de manutention particuliers et la TPS.	**TOTAL GÉNÉRAL**	

Le chèque ou mandat-poste doit être fait à l'ordre du Receveur général du Canada – Publications. Les clients canadiens paient en dollars canadiens; les clients à l'étranger paient le montant total en dollars US tirés sur une banque américaine.

Pour un service plus rapide, composez **1-800-267-6677** **Comptes VISA et MasterCard**

PF
092147
1993-03

This order coupon is available in English upon request

Statistique Canada Statistics Canada

Canada

Catalogue 11-528E, No. 2 – Occasional

Environmental Perspectives

2

Studies and Statistics

Statistics Canada   Statistique Canada

Canada

Data in Many Forms . . .

Statistics Canada disseminates data in a variety of forms. In addition to publications, both standard and special tabulations are offered. Data are available on CD, diskette, computer print-outs, microfiche and microfilm, and magnetic tapes. Maps and other geographic reference materials are available for some types of data. Direct online access to aggregated information is possible through CANSIM, Statistics Canada's machine-readable database and retrieval system.

How to Obtain More Information

Inquiries about this publication and related statistics or services should be directed to:

System of National Accounts,
National Accounts and Environment Division,
Statistics Canada, Ottawa, K1A 0T6 (Telephone: 1-613-951-3640) or to the Statistics Canada reference centre in:

Halifax	(1-902-426-5331)	Regina	(1-306-780-5405)
Montreal	(1-514-283-5725)	Edmonton	(1-403-495-3027)
Ottawa	(1-613-951-8116)	Calgary	(1-403-292-6717)
Toronto	(1-416-973-6586)	Vancouver	(1-604-666-3691)
Winnipeg	(1-204-983-4020)		

Toll-free access is provided in all provinces and territories, **for users who reside outside the local dialing area** of any of the regional reference centres.

Newfoundland, Labrador Nova Scotia, New Brunswick and Prince Edward Island	1-800-565-7192
Quebec	1-800-361-2831
Ontario	1-800-263-1136
Saskatchewan	1-800-667-7164
Manitoba	1-800-661-7828
Southern Alberta	1-800-882-5616
Alberta and Northwest Territories	1-800-563-7828
British Columbia and Yukon	1-800-663-1551
Telecommunications Device for the Hearing Impaired	**1-800-363-7629**
Toll Free Order-only Line (Canada and United States	**1-800-267-6677**

How to order Publications

This and other Statistics Canada publications may be purchased from local authorized agents and other community bookstores, through the local Statistics Canada offices, or by mail order to Marketing Division, Sales and Service, Statistics Canada, Ottawa, K1A 0T6.

(1-613-951-7277)
Facsimile Number (1-613-951-1584)
Toronto Credit Card Only (1-416-973-8018)

Standards of Service to the Public

To maintain quality service to the public, Statistics Canada follows established standards covering statistical products and services, delivery of statistical information, cost-recovered services and service to respondents. To obtain a copy of these service standards, please contact your nearest Statistics Canada Regional Reference Centre.

Statistics Canada
National Accounts and Environment Division
System of National Accounts

Environmental Perspectives

2

Studies and Statistics

Published by authority of the Minister responsible for Statistics Canada

June 1995

Price: Canada: $35.00
United States: US$42.00
Other Countries: US$49.00

Catalogue No. 11-528E, No. 2

ISBN 0-660-15573-7

Ottawa

Version française de cette publication disponible sur demande (n^o 11-528F, n^o 2 au catalogue).

Note of Appreciation

Canada owes the success of its statistical system to a long-standing co-operation involving Statistics Canada, the citizens of Canada, its businesses and governments. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Over 50% recycled paper including 10% post consumer fibre

Canadian Cataloguing in Publication Data

Main entry under title:

Environmental Perspectives

(Studies and statistics)
Issued also in French under title:
Perspectives sur l'environnement.
ISBN 0-660-15573-7
CS11-528E, no. 2

1. Environmental indicators -- Canada.
2. Environmental protection -- Canada.
3. Conservation of natural resources -- Canada.
I. Statistics Canada. National Accounts and Environment Division.
II. Statistics Canada. System of National Accounts Branch.
III. Title.
IV. Series.

HC113.5 E58 1995 333.7'0971
C95-988015-1

Table of Contents

Symbols

The following standard symbols are used in Statistics Canada publications:

..	figures not available
...	figures not appropriate or not applicable
-	nil or zero
- -	amount too small to be expressed
p	preliminary figures
r	revised figures
x	confidential to meet secrecy requirements of the Statistics Act

Prefixes of the International System of Units

Prefix	Multiplication factor	
peta	10^{15}	1 000 000 000 000 000
tera	10^{12}	1 000 000 000 000
giga	10^{9}	1 000 000 000
mega	10^{6}	1 000 000
kilo	10^{3}	1 000
hecto	10^{2}	100
deca	10^{1}	10
deci	10^{-1}	0.1
centi	10^{-2}	0.01
milli	10^{-3}	0.001
micro	10^{-6}	0.000001
nano	10^{-9}	0.000000001
pico	10^{-12}	0.000000000001

Abbreviations

1986$	1986 dollars
^{o}C	degrees Celsius
cm	centimetre
ha	hectare
hr	hour
kg	kilogram
km	kilometre
km^2	square kilometre
kPa	kilopascal
kt	kilotonne
L	litre
m	metre
m^2	square metre
m^3	cubic metre
mg	milligram
mm	millimetre
Mt	megatonne
ng	nanogram
nec	not elsewhere classified
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
SIC	Standard Industrial Classification
t	metric tonne
tC	metric tonne of carbon
TJ	terajoule
US$	United States dollars

Preface

Environmental Perspectives: Studies and Statistics is devoted to disseminating the results of analytical projects and development of data detailing the relationship between the environment and the economy. This publication appears annually between issues of the quinquennial ***Human Activity and the Environment***, which was last published in 1994.

Whereas ***Human Activity and the Environment*** is a comprehensive compendium of environmental-economic data, this publication presents a selection of data and analysis that reflect the current environmental statistics program at Statistics Canada.

The first chapter in this edition provides an overview of the three main directions of work in Statistics Canada's environmental statistics program: Environmental Information Systems, Environmental Surveys and Environmental Accounts. The remainder of the publication is organized according to these three themes.

Environmental Information Systems

- Chapter 2 provides an example of how the environmental information system was used to measure the impact of changing socio-economic trends on a selected geographic ecosystem: the Waterton Lakes National Park.

Environmental Surveys

- Chapter 3 highlights some results from the 1993 Local Government Waste Management Survey.

Environmental Accounts

- *Natural resource stock accounts:* In Chapters 4 and 5 the joint pilot projects between the Ontario Ministry of Natural Resources and Statistics Canada on the quantification and valuation of timber stocks for the province of Ontario are described. Chapter 6 assesses Canada's endowment of coal, by province, in both physical and value terms.
- *Natural resource use accounts*: Chapter 7 presents the development of a resource use account for water which follows the Canadian Input-Output Account model.
- *Waste output accounts*: Chapter 8 presents carbon dioxide emissions for 1981-1990 based on the Canadi-Input-Output Account model.This work demonstrates how waste output data are linked to economic activity.
- *Environmental protection expenditure accounts:* Chapter 9 presents environmental protection expenditures made by each of the levels of government in Canada.

Finally an annex provides a set of broad economic, social and environmental statistics for Canada's provinces and territories.

Acknowledgements

This publication was prepared by the Environmental Statistics sub-division of the National Accounts and Environment Division under the direction of Philip Smith, Director and Cynthia Baumgarten, Assistant Director. The editor was Rick Moll.

The authors were:

Alice Born
Murray Cameron
Christine de Boer
Véronique Dumas
Susan Ecclestone
Gerry Gravel
Tony Johnson
Anik Lacroix
Greg Lawrance
Rick Moll
Marcia Santiago
Philip Smith
Robert Smith
Doug Trant
Hélène Trépanier
Kevin Van Tighem

Dale Austin, Tracey Bushnik, Phillip Fong, Jeff Fritzsche, Joe Filoso, Craig Gaston, Julie McAuley and Debbie MacDonald all provided valuable technical help and/or editorial advice. The French translations were edited by Pierre Gagnon, Tara Gray, Jocelyn Lapierre, Anik Lacroix and Hélène Trépanier. The marketing and technical assistance of Mitzi Ross and Susie Boyd is also acknowledged.

1 Statistics Canada's Environmental Statistics Program

by Philip Smith[1]

Introduction

Resource depletion and environmental degradation are widely recognized today to be serious and growing problems. To understand and address these problems, governments and citizens need good environmental statistics. Yet the world's statistical systems, developed mostly this century, were not designed with this requirement in mind. They were set up primarily to provide information about human population and socio-economic development rather than about the environment - although these fields are certainly quite intimately related. Only within the last decade or two, as environmental issues have taken on more prominence, have statistical agencies started to reorient their focus.

The term 'environmental statistics' encompasses a vast breadth of subjects. It refers, firstly, to quantitative information about the physical environment: pollutant concentrations in air, water and soil, the size and character of forest, fish, wildlife and mineral stocks and the extent of biodiversity. But it also applies to economic, or value data: expenditures by businesses, households and governments for pollution abatement and control facilities and equipment, spill cleanup costs, land, lumber, fish and mineral market values and so on. Moreover, the phrase can refer to a variety of other related socio-economic data: on modes of transport, energy intensities, recycling behaviour, the extent of fertilizer and pesticide usage, cancer incidence and so on. Time series data provide information about changes related to the environment while spatial data shed light on the geographical distribution of environmental assets and problems. Environmental statistics provide us with an evolving picture of the physical world we live in and connect the main elements in that picture to the everyday actions of humanity.

In Canada, environmental data are collected by several federal, provincial and municipal government departments. The ministries of forestry, fisheries, energy, mines, agriculture, health, transportation, industry and, of course, environment all have monitoring and regulatory responsibilities that relate partly to the environment and that, of necessity, involve the gathering of environmental information. Statistics Canada also collects environmental data through its survey activities, and, equally importantly, it has responsibility for assembling data from other departments in the form of integrated environmental statistics.[2]

This chapter describes Statistics Canada's environmental statistics program. It begins with a short history of the program's evolution over the last two decades. Then the main elements of the current program - surveys, administrative data and environmental accounts - are discussed. This chapter concludes with some thoughts about future directions for the program.

History of the environmental statistics program

The *raison d'être* of Statistics Canada's environmental statistics program is to compile and publish integrated statistical information about the state of Canada's natural environment and the manner in which it affects and is affected by human activities. Environmental statistics are derived in four ways:

- by recasting existing household and business survey information, collected for other purposes, in a manner that makes it more useful for the analysis of environmental issues;
- by launching new surveys directly addressing questions that are of interest from an environmental perspective;
- by exploiting administrative and regulatory databases maintained by federal, provincial and municipal government departments as part of their normal responsibilities; and
- by constructing new time series estimates through the application of scientific and technical coefficients to socio-economic data.

During the initial years of the program, in the mid 1970s, efforts concentrated on the first of these approaches: making

1. The author is Director of the National Accounts and Environment Division at Statistics Canada. A version of this paper was presented at the 1994 joint statistical association meetings, in a session entitled "Environmental Assessments in the NAFTA Era", on August 15, 1994.

2. Article 3 of the Statistics Act, legislated in 1918 and amended several times since, establishes Statistics Canada:
a) to collect, compile, analyze, abstract and publish statistical information relating to the commercial, industrial, financial, social, economic and general activities and condition of the people;
b) to collaborate with departments of government in the collection, compilation and publication of statistical information, including statistics derived from the activities of those departments;
c) to take the census of population of Canada and the census of agriculture of Canada;
d) to promote the avoidance of duplication in the information collected by departments of government; and
e) generally, to promote and develop integrated social and economic statistics pertaining to the whole of Canada and to each of the provinces thereof and to coordinate plans for the integration of those statistics.

use of existing survey data to shed light on how human activities exert stress on natural ecosystems. The results of this early work were published in March 1978 in a new compendium called ***Human Activity and the Environment*** (Statistics Canada Cat. No. 11-509E).

A new geographical framework based on watersheds (or drainage basins)[1] was adopted in this publication. By reorganizing existing data within watershed regions instead of the more usual census enumeration areas or political boundaries of provinces and municipalities, the information could be seen in quite a different light. Watershed boundaries, defined by the Water Survey of Canada Division of Environment Canada, are coded and transferred to the National Topographic System maps used by Statistics Canada. Census data are then aggregated by including, in each drainage region, the data for all census enumeration areas for which the population centroid (essentially a centre of gravity concept) lies within the watershed boundary. Similarly, manufacturing data from the survey of manufacturing establishments are allocated to watersheds based on the Standard Geographical Code of the municipality in which the establishment is located.

This first edition of ***Human Activity and the Environment*** presented a collection of statistics on population, agriculture, forests, fisheries, transportation, manufacturing and energy. A variety of relevant time series were brought together in an environmental database and much of the information was displayed by watershed, although in certain cases, particularly where geographical detail was unavailable, data were presented at the all-Canada level only. Industrial activities were reclassified according to the degree of stress they exert on the environment:

- *High stressor industries* were those associated with the initial stages of manufacturing, characterized by large-scale bulk refinement and concentration processing of raw materials drawn from the environment. These industries typically require high-energy input per unit of output and are often identified as the high polluters.
- *Medium stressor industries* were largely those associated with the second level of processing where materials undergo a transformation for specialized purposes required for the next and final stage of production, although some finished-goods manufacturing is included as well where special polluting problems exist.
- *Low stressor industries* were mostly those that produce final goods, with processes distinguished by relatively low material and energy inputs and high labour inputs per unit of output. In terms of process activity, they tend to fall under the headings of assembly, construction or packaging.

The environmental statistics program moved in some new directions during the early and mid-1980s. For one thing, several new administrative data sources were explored and developed, beyond the Statistics Canada survey sources already being used. For another, there was a perceived need for an improved organizing framework for environmental statistics, which led to the development of the "Stress-Response Environmental Statistical System" (STRESS)[2]. This framework recognizes three main elements: (1) stresses imposed on the environment by human actions and events in nature, (2) responses by the environment to these stresses, and (3) actions by people to modify the character and intensity of the stresses that their activities exert on the environment. The system is summarized in Table 1.1.

The second edition of ***Human Activity and the Environment***, issued in March 1986, was organized around the STRESS framework, with chapters on population, harvesting, extraction and depletion of non-renewable resources, environmental restructuring, the generation of waste products, the responses of biological species to environmental stress, and collective and individual human responses. The statistical information it provided was greatly expanded compared to the first edition.

Tabulations were arrayed by watershed, as in the first edition, and also by ecozone[3] and by province. Statistics were also included on the physiography and climate of Canada and on major geophysical and meteorological events affecting the environment. The chapter on the generation of waste products was the largest and most ambitious, dealing separately with mining, manufacturing, thermal energy generation, transportation activity, household consumption and municipal waste. It drew upon a wide range of Statistics Canada data sources including the censuses of mines and manufactures, the surveys of electrical power and industrial consumption of energy, a wide variety of transportation survey data and population census data. Several databases from Environment Canada were also utilized, including most of those listed in Text Box 1.1. Other chapters presented information from Canada's Forest Inventory (established by the Canadian Forest Service), the census of agriculture, the survey of fertilizer trade, statistical databases main-

1. Watersheds are the heights of land which divide drainage basins, river basins or valleys, which in turn refer to surface drainage catchment areas. For example, a mountain range can form a drainage basin boundary separating two catchment areas. Drainage basins form a hierarchy, with five major basins at the top, draining into the Atlantic Ocean, Hudson Bay, the Arctic Ocean, the Pacific Ocean and the Gulf of Mexico. Beneath these five basins are 218 sub-drainage basins and 917 sub-sub-drainage basins. This geographical framework is useful for environmental analyses because water is vital for all life and flowing water conducts pollutants between ecosystems.
2. See Friend and Rapport, 1979 and Friend, 1981.
3. Ecozones are natural regions delineated by distinctive sets of biotic resources (flora and fauna) and physical resources (soils, bedrock, physiography, climate). They constitute fairly homogeneous geographical spaces that are useful for monitoring the impact of natural and human stresses on the environment. At the highest level, there are 15 ecozones. Beneath these are 47 ecoprovinces, divided into 177 ecoregions, divided into 5,395 ecodistricts. Ecozones, like drainage basins, transcend national boundaries and there is a need for better international standards in this area.

Table 1.1
The STRESS Organizational Framework

Stresses on the environment				Environmental response statistics	Human response statistics
Stressor categories	Activity categories	Activity statistics	Environmental stress statistics		
Natural source stresses	Geophysical and meteorological events and processes	Floods, storms, earthquakes	Rates of erosion, landscape change	Changes in air, water, soil characteristics Changes in biotic state	Environmental restructuring
Harvesting	Agriculture Forestry Fisheries	Production	Changes in soil characteristics Depletion of stocks	Changes in biotic state including population size, regenerative capability	Conservation Changes in methods of farming, harvesting Legislation, fish quotas
Extraction and depletion of non-renewable resources	Metals and non-metallic minerals Fossil fuels	Extraction	Depletion of resources Substitution	Substitution for scarce resources leads to impacts indirectly from wastes and restructuring associated with use of substitutes	Conservation
Environmental restructuring	Land conversion Restructuring water systems Transport networks Resource development	Construction of homes, dams, reservoirs, railways, highways Exploration for resources	Land converted, changed in character	Changes in air, water, soil characteristics Changes in biotic state including species diversity, population size (due to habitat change)	Changes in rate and location of land conversions Land use legislation Park creation
Generation of waste residuals	Mining Manufacturing Energy generation Transportation Households	Production Consumption Vehicle movements	Waste generated Emissions of wastes to air, water, soil Disposal of toxics	Changes in air, water, soil characteristics Changes in biotic state including species diversity, population size Human health effects	Pollution abatement through process change, activity termination Legislation Conservation
Population	Population dynamics	Population growth, migration			Population control, resettlement

tained by the international fisheries commissions and Fisheries and Oceans Canada, the International Commission on Large Dams, the Canadian Wildlife Service and the National Museums of Canada.

Text Box 1.1
Environment Canada Databases

- Canada Land Inventory (CLI)
- Hydrometric Database (HYDAT)
- Industrial Water Use Survey (INSURVS) database
- Municipal Water Use Database (MUD)
- Municipal Waterworks and Wastewater Database (MUNDAT)
- National Air Pollution Surveillance (NAPS) database
- National Analysis of Trends in Emergencies (NATES) database
- National Emissions Inventory System (NEIS) database
- National Inventory of Hazardous and Toxic Wastes (NIHTW) database
- National Pollutant Release Inventory (NPRI) database
- National Water Quality Database (NAQUADAT)
- Ocean Dumping Permit (ODUMP) control database
- Park Use Related Data System (PURDS) database
- Residual Discharge Inventory System (RDIS) database
- Regulated industries databases (pulp & paper, non-ferrous foundries, ferrous foundries, petroleum refining, mines)

The year 1986 also marked the publication of the first ***State of the Environment Report for Canada***, a joint effort by Statistics Canada and Environment Canada.[1] This volume provided a comprehensive and wide-ranging assessment of the condition of Canada's farmlands, forests, waters, wildlife and other natural resources and of the implications of changes in those conditions for Canadians. It adopted the ecozones framework and made considerable use of the statistical information presented in ***Human Activity and the Environment***.

In the late 1980s, Statistics Canada announced the establishment of a new spatially referenced database known as the Environmental Information System (EIS). Structured as a geographical information system, this database contains socio-economic and biophysical microdata from the censuses of population and agriculture, from the surveys of

1. The working relationship between Statistics Canada and the federal and provincial environment departments has grown stronger through the 1980s and into the 1990s. Statistics Canada contributed substantially to the most recent ***State of the Environment Report for Canada***, issued by Government of Canada in 1991 and has assisted with the preparation of several provincial reports as well, Statistics Canada has also worked closely with the Canadian Council of Ministers of the Environment (CCME) on a number of environmental statistics projects.

manufacturing and mining and from a number of other sources. The EIS can be used to analyze, through mapping techniques and cross-tabulations, environmental problems on various scales ranging from national issues to local watershed concerns. Aggregations are easily accomplished for studies relating to particular river basins, ecoregions or urban areas. Since in most cases comparable data are available for all of the census years 1971, 1976, 1981, 1986 and 1991, the database can answer questions about changes over time as well as about spatial dispersion. Some examples of EIS applications have been an analysis of the impact of creeping urbanization on the Jock River valley near Ottawa, a study of land use change around Riding Mountain National Park in Manitoba and an assessment of population exposure to air pollutants in metropolitan Toronto. Custom tabulations from this database, sufficiently aggregated to protect respondent confidentiality, are available to the general public.[1]

The third edition of ***Human Activity and the Environment*** was published in September 1991. It updated the statistics presented in the previous edition with data from the 1986 census and introduced some new tables to address emerging environmental issues, notably greenhouse gas emissions and the spread of the zebra mussel in the Great Lakes. The stress analysis that had been applied to manufacturing industries in previous editions of the book was extended and improved upon considerably, using an input-output approach. In addition, the STRESS framework, used in the 1986 edition, was revamped and renamed the Population-Environment-Process (PEP) framework. It is illustrated in Figure 1.1.

In the PEP framework, the key elements are the population, the socio-economic system and the natural environment. Each element is characterized by stocks (or states, represented by barrels), processes (or activities, represented by boxes) and interactions with other components (flows or restructuring, represented by arrows). There are four state variables in the system: the population, the produced capital stock, natural assets (the non-produced capital stock) and the stock of waste products. Three kinds of processes involve and affect these state variables: population processes (birth, death, migration), socio-economic processes (production and consumption) and natural processes (storms, earthquakes, photosynthesis). Finally, interactions occur among the states and processes in the form of flows (ground water withdrawals, harvest of forests, sport fishing) and restructuring (the impact of human visits to wilderness areas, agricultural development, dam-building).

More recently, there have been further additions and improvements to the program. An annual publication[2] entitled ***Environmental Perspectives: Studies and Statistics*** (Statistics Canada Cat. No. 11-528E) made its début in March 1993. It contained a set of thirteen articles reviewing recent survey and analytical work at Statistics Canada in the general area of environmental statistics.[3]

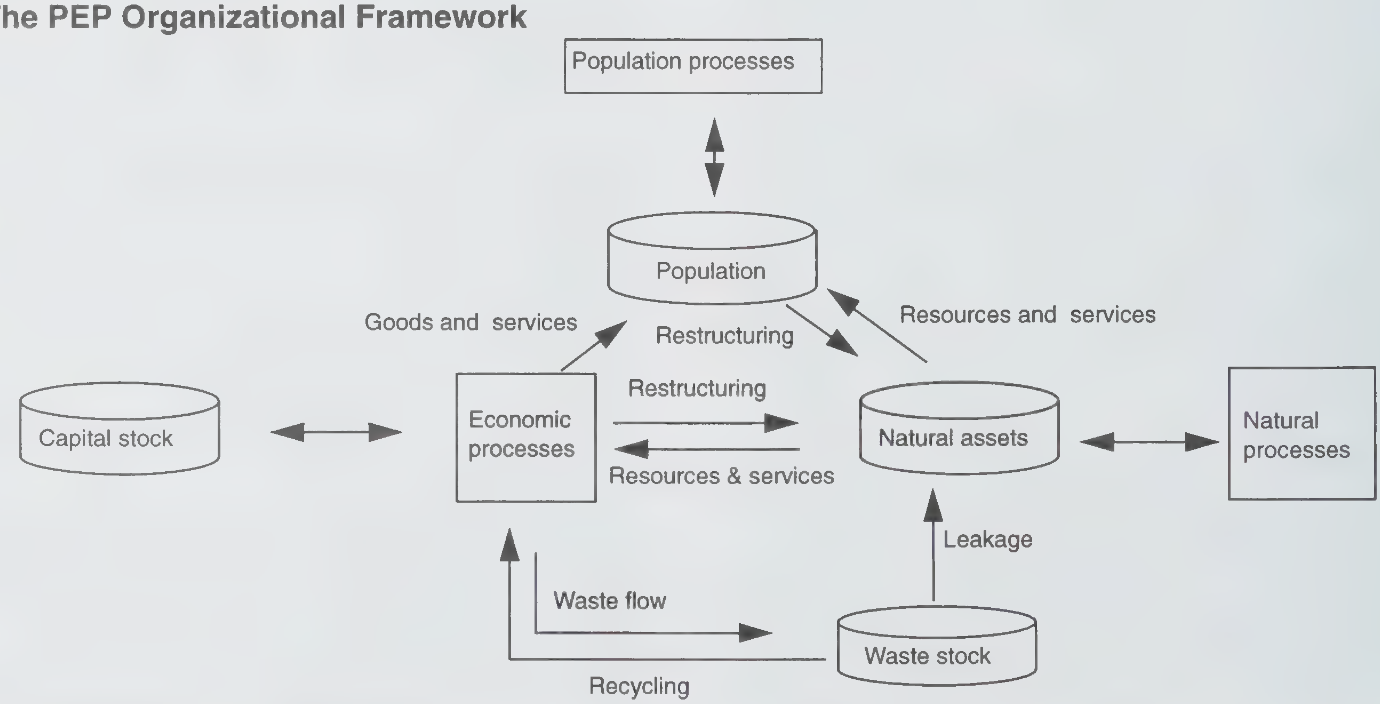
1. Selected data from the EIS are also available on E-Stat, Statistics Canada's CD-ROM product for use by schools.

2. ***Human Activity and the Environment*** is normally published at five year intervals, following the quinquennial census, and ***Environmental Perspectives*** will be published in the four intervening years.

3. It is planned that in future years ***Environmental Perspectives*** will also contain a varied collection of environmental time series indicators.

Figure 1.1

The PEP Organizational Framework



The fourth edition of ***Human Activity and the Environment*** was published in June 1994, containing fresh data from the 1991 census. The PEP framework continues to provide the organizing structure for the book. Results from several pilot surveys designed to fill important environmental data gaps are also included and there are new chapters outlining recent work in the area of environmental accounting and providing international and interprovincial comparisons.

While new survey work has been severely constrained by tight budgets, substantial progress is being made, as will be discussed in the next section. Renewed attention is also being focused on the exploitation of administrative data sources, as will be explained in the subsequent section. In addition, the environmental statistics program was expanded significantly in 1991 when the government gave Statistics Canada a new mandate to develop a comprehensive set of environmental accounts, as a satellite to the existing Canadian System of National Accounts. This recent development will be reviewed in the last major section of this chapter.

Surveys

Statistics Canada is mandated to conduct surveys of Canadian households, businesses and governments,[1] and to report continuously to the general public on the results. The survey program includes comprehensive censuses of population and agriculture, carried out every five years. In addition, there are annual, quarterly and monthly surveys of manufacturing, mining, agriculture, construction, transportation, finance, and other industries; of prices; of employment and earnings; of the labour force status of the population; of social conditions, including health, welfare and justice matters; and of education, culture and tourism. Surveys on other special topics are also conducted from time to time.

Few of the surveys conducted by Statistics Canada have an explicitly environmental focus, yet many provide information that is quite valuable for environmental analyses. The census of population shows where the environmental stresses associated with urban growth are being most keenly felt. The census of agriculture yields important data about land use change, and about pesticide and fertilizer usage, that, organized by watershed or by ecozone, can be associated with changes in water quality and human health. Other social and economic surveys on family expenditures, transportation, trade, industrial production, health and a host of other subjects are also relevant.

In the past few years, Statistics Canada has put increasing emphasis on the development of new surveys to fill key environmental data gaps. Surveys have been conducted in five areas:[2]

1. There are roughly 10 000 000 households, 1 500 000 businesses and 5 000 governments in Canada.

1. *Households and the environment*[3]

In this survey, households are asked about their access to and usage of recycling, special waste disposal programs, disposable diapers, lawn and garden pesticides and fertilizers, programmable thermostats, energy-efficient lighting, low-flow shower heads, water purifiers, bottled water, and public transit. The survey is conducted as an adjunct to the labour force survey.

2. *Pollution abatement and control expenditures by business and government*[4]

The purpose of this survey is to gather information from businesses and government departments about annual capital and operating expenditures on pollution abatement and control (PAC) facilities and equipment. PAC expenditures are defined as outlays for retrofit construction and/or machinery, meaning facilities or equipment that are separately identifiable, that have been installed for PAC purposes and that are not an integral part of the plant production equipment. The survey also seeks information about quantities of major substances abated or controlled and about sales and own use of PAC-recovered materials.

3. *Private sector waste management industry*[5]

This survey gathers data pertaining to the operating revenues, expenses, employment, capital expenditure and tonnage of waste material processed by business establishments engaged in the collection, haulage, disposal and/or recycling of waste products.

4. *Municipal government waste management practices*[6]

In this survey, municipalities of all types are questioned about their practices and associated costs with respect to the collection, transportation and disposal of garbage, recycling and the handling of hazardous waste. The survey is paired with the private sector waste management industry survey, as some municipalities contract out for waste management services while others provide the services directly.

5. *Packaging*[7]

The national packaging survey collects information from business establishments in all major industries on their use, reuse, recycling and disposal of industrial packaging. Some 32 packaging categories are defined in the survey, spanning six broad groups of materials: plastic, wood, textiles, glass, metal and multi-material packaging.

These surveys are pilot efforts. The first has been done three times, the fourth and fifth have each been conducted twice and the other two, only once. Means are being sought

2. Two other environmental surveys, ***Water Use in Canadian Industry*** and ***The Importance of Wildlife to Canadians***, have been conducted by Statistics Canada several times over the past two decades, under the sponsorship of Environment Canada.
3. Statistics Canada, 1994.
4. Statistics Canada, 1992a.
5. Statistics Canada, 1992c.
6. Statistics Canada, 1993a, p. 69-74.
7. Statistics Canada, 1993a, p. 63-66.

to establish them all on a regular basis so that time series can be developed.

There are many other areas where more survey information is required. One is waste products, where better time series data are needed on emissions, by type of material, by industry. The National Pollutant Release Inventory (NPRI) survey, being developed by Environment Canada, is expected to fill part but not all of this data gap. Improved information about garbage generation, by type of material, by municipality is also needed. More regular and complete survey data are required as well in the area of environmental expenditures, on both the demand and the supply sides. There is increasing policy interest in the characteristics of the 'industry' that supplies the market for pollution abatement and control facilities and equipment.[1] Wildlife is yet another area where good data are lacking, although many of the requirements here can only be satisfied by scientific inquiries, rather than business and household surveys.

Administrative data

Statistics Canada draws a lot of statistical information from administrative data sources. Customs data, income and sales tax records, public accounts and regulatory data all yield detailed information with relatively high quality and high frequency, coupled with relatively low marginal acquisition cost and no marginal response burden. Under the Statistics Act, the Bureau has the responsibility and the authority to access these data sources and to produce and publish statistical series from them.[2]

Regulatory data from Environment Canada are a very important source of environmental information. As was noted previously, ***Human Activity and the Environment*** includes a wide range of statistics drawn from the MUNDAT, NAPS, NATES and NAQUADAT regulatory databases and some others. Statistics Canada also makes use of administrative data from the Canadian Forestry Service, Fisheries and Oceans Canada, the Canada Centre for Remote Sensing and several other agencies.

Still, there is an enormous wealth of environmental information remaining in administrative databases that has not yet been brought to light and exploited. Finding and extracting this information is not a simple task, since the datasets are widely dispersed within and among government departments and since they are stored in a wide variety of often poorly documented formats, using differing concepts.

Substantial progress has been made recently in identifying these databases and exploring their potential. Statistics Canada has conducted two exhaustive searches, one of federal government departments and another of provincial government departments, to catalogue administrative databases relevant for environmental monitoring and analysis. The results of these searches are published in two volumes, ***Databases for Environmental Analysis: Government of Canada*** (Statistics Canada Cat. No. 11-527E) and ***Databases for Environmental Analysis: Provincial and Territorial Governments*** (Statistics Canada Cat. No. 11-529E). These 'meta' databases contain characteristic information about each database: a description of the contents and purpose, the name and address of contact persons, the geographical coverage, the data acquisition method, the update frequency, the period for which data are available, the database hardware and software configuration, the output formats, the language(s) used, any restrictions on access and pricing information. These two 'databases of databases' are being maintained in electronic form, which facilitates rapid keyword searching, and they will be updated periodically in the future. They point to many rich lodes from which new statistical series can be developed.

Environmental accounts

About four years ago, Statistics Canada was asked by the Government of Canada to begin work on a new system of natural resource and environmental accounts, to be developed as a satellite to the existing Canadian national accounts. Funds were provided for the project as part of a broad government policy initiative, referred to as Canada's Green Plan.[3] Given the size and diversity of Canada and its resource base, the job of developing this new body of statistics is a very large one. It is anticipated that the work to develop the new accounts will take several years.

The project is moving ahead on schedule.[4] So far, particular effort has been concentrated on developing natural resource accounts, for both renewable and non-renewable resources. First priority has been given to oil and gas reserves and timber assets, two of Canada's most important natural resources. Some exploratory work also has been done on reserves of metal ores and other minerals, on land accounts and on wildlife accounts. Pollution and waste statistics and their linkage to economic activity have also received some attention, particularly in

1. The 'environmental industry' is actually a rather ill-defined mixture of industries from the Standard Industrial Classification (SIC), each of which produces goods or services having an environmental character. In this respect it is analogous to the 'tourism industry'. There is no 'environmental industry' as such in the SIC. However, at the time of the next SIC revision, planned for 1997, new and growing industries of particular interest from an environmental perspective will be more fully and carefully delineated.
2. Statistics Canada is required under the law to protect the confidentially of individual records vigilantly, by aggregating the information sufficiently.
3. See Government of Canada, 1990. The Green Plan is a comprehensive, multi-year government policy initiative involving actions in the areas of human health protection, water care and restoration, smog and other waste reduction, sustainable development of forest, agriculture and fishery resources, protection of unique ecological areas and wildlife, the reduction of global warming pressures, improved handling of environmental emergencies and provision of more complete public information about Canada's environment.
4. For a more detailed outline of the progress to date on the environmental accounting project, see Smith, 1994.

the area of greenhouse gas emissions. Resource use accounts for energy, water and some other materials are under development and a comprehensive set of environmental protection expenditure accounts is planned.

The environmental component will be a satellite[1] of the existing Canadian national accounts with four distinct components:

- *natural resource stock accounts*, recording the known size and composition of Canada's natural resource assets as they evolve over time, in both physical and monetary terms;
- *natural resource use accounts*, recorded in physical terms, showing when and how non-produced goods and services are brought into the economic sphere and used in production and consumption activities, and highlighting the role of selected produced goods that are important in analyses of certain environmental issues;
- *waste output accounts,* recorded in physical terms, reporting the types and quantities of waste products that are generated in the economy and relating these to the flow of output; and
- *environmental protection expenditure accounts* identifying current and capital expenditures, by business, government and households, that are intended to conserve or protect natural resources and the environment.

The broad structure of the environmental accounts and their relationship to the conventional Canadian national accounts are shown in Figure 1.2. The natural resource stock accounts, expressed in monetary terms, are an addition to the national balance sheet. The existing Canadian national balance sheet and flow accounts include only financial and produced assets. The plan is to develop physical and monetary natural resource stock and flow accounts according to the classification suggested in the revised SNA,[2] that is, for each of the asset categories shown in Text Box 1.2.

The natural resource use accounts will show the physical quantities of various natural resources that are used by industries to produce their outputs, and by consuming households. As such, these accounts provide additional detail for selected rows in the use matrix of the input-output tables converted from monetary terms to physical units. For natural resource commodities, the total use is carried over to the 'other changes in volume of natural resource assets' statement, where it helps account for changes in natural resource reserves over time. For other environmental commodities such as air and water, there are no corresponding stock accounts, although associated environmental quality measures can be developed and, possibly, linked to the resource use and waste output accounts.

Text Box 1.2

SNA Asset Classification

- Tangible non-produced assets
  - Land
    - Land underlying buildings and structures
    - Land under cultivation
    - Recreational land and associated surface water
    - Other land and associated surface water
  - Subsoil assets
    - Coal, oil, natural gas and crude bitumen reserves
    - Metallic mineral reserves, notably copper, nickel, zinc, lead, gold, silver, molybdenum, iron and uranium ores
    - Non-metallic mineral reserves, notably gypsum, potash, asbestos, salt, limestone, sand and gravel
  - Non-cultivated biological resources
    - Forest timber
    - Wildlife, notably fish, moose, deer and caribou
  - Water resources

The waste output accounts will record emissions of waste products, whether solid, liquid or gaseous, generated by industries, governments and households. These accounts will be developed in physical terms only. They can be thought of as a counterpart of the resource use accounts, the two together providing an integrated description of natural resources flowing through and being transformed by the economic system. Sub-accounts may also be developed for international 'trade' in waste products and for accumulations of waste.[3]

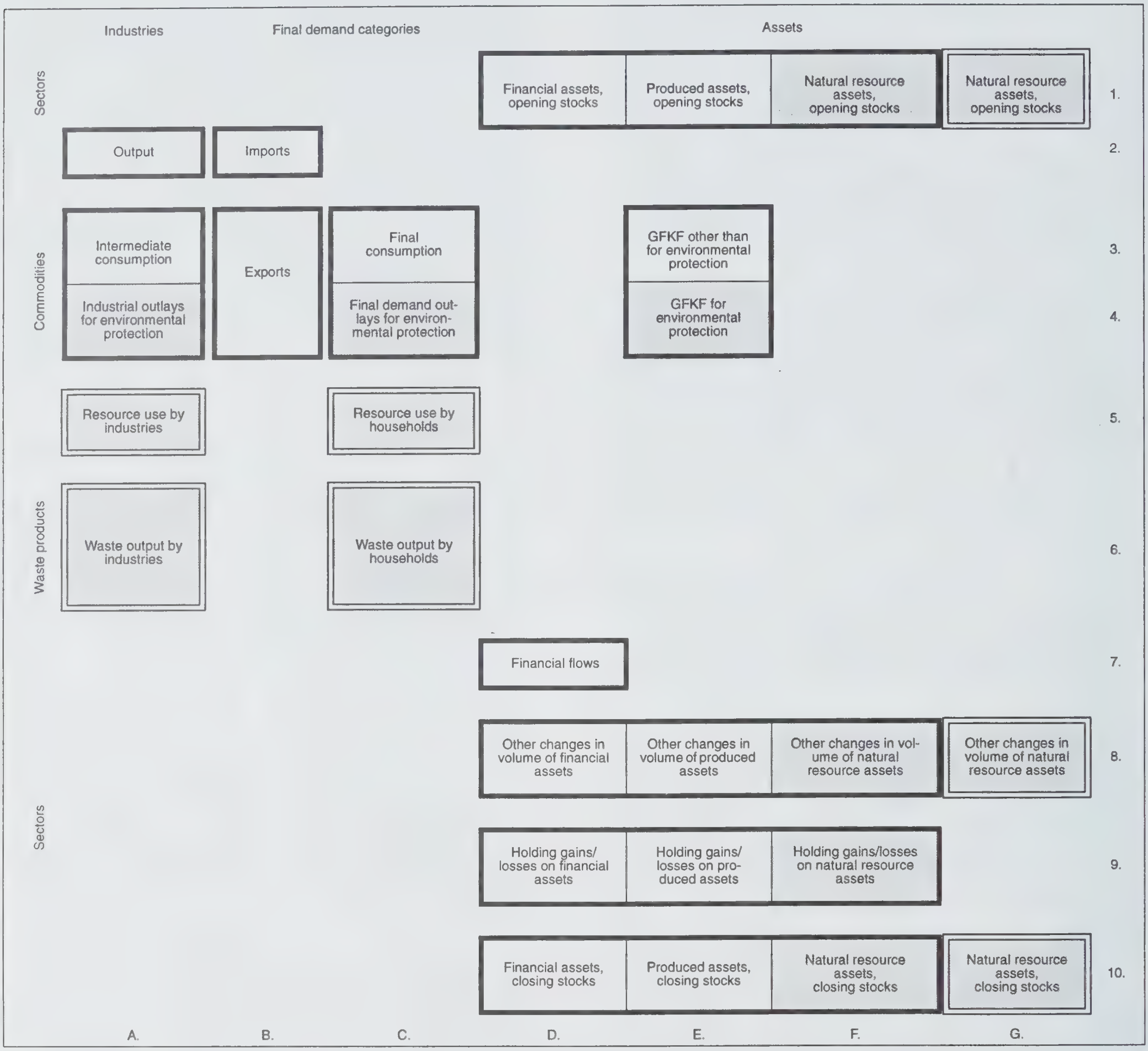
Finally, the environmental protection expenditure accounts will disaggregate the existing gross output time series in the core national accounts to show 'defensive' or 'protective' outlays separately from other production. Initially these accounts will be restricted to 'end-of-pipe' type expenditures.[4]

This framework bears many similarities to the System of Integrated Environmental and Economic Accounting (SEEA), proposed by the Statistical Division of the United Nations.[5]

1. United Nations *et al.*,1993a, chapter XXI, contains a discussion of satellite accounts in general and environmental satellite accounts in particular: "Typically satellite accounts or systems allow for: (a) the provision of additional information on particular social concerns of a functional or cross-sector nature; (b) the use of complementary or alternative concepts, including the use of complementary and alternative classifications and accounting frameworks, when needed to introduce additional dimensions to the conceptual framework of national accounts; (c) extended coverage of costs and benefits of human activities; (d) further analysis of data by means of relevant indicators and aggregates; and (e) linkage of physical data sources and analysis to the monetary accounting system." (p. 489.)
2. See United Nations *et al.*,1993b, annex V, part D.
3. Garbage is routinely shipped for disposal between Canada and the United States, depending on where the tipping fees are lowest. It would be useful to identify these shipments within the satellite account, as well as any concentrated accumulations of garbage or hazardous waste products.
4. By 'end-of-pipe' expenditures is meant outlays for non-integrated equipment or facilities acquired specifically for the purpose of pollution abatement and control. It is often more difficult to distinguish PAC expenditures when pollution abatement is a built-in function of the associated equipment and facilities.
5. United Nations, 1993a.

Figure 1.2

Natural Resource and Environmental Accounts within the Canadian National Accounts*



* Shaded areas are part of the environmental satellite account. In some instances these parts are simply decompositions within the existing core national accounts (row 4). In others they represent additions to the core accounts in line with the new UN-SNA standard (column F). Finally, in some cases they represent enhancements for the purposes of the satellite account only (rows 5 and 6 and column G). Boxes with solid black borders represent accounts measured in monetary units; boxes with double-line borders represent accounts measured in physical units. GFKF signifies 'gross fixed capital formation'.

A major difference though is that in the SEEA, several items are moved up from the 'other changes in volume of natural resource assets' account and netted against gross fixed capital formation (GFKF) and gross value added, defining a new aggregate, 'environmentally-adjusted net domestic product' (EDP). The Canadian satellite accounts will not, at least not in their initial versions, redefine or supplement existing SNA aggregates such as gross or net domestic (or national) product, although the accounts will provide much of the information necessary for those who may wish to calculate such 'green aggregates'. It will take many years of data development, research and professional discussion before meaningful, reliable and credible aggregates of this kind are possible from a statistical perspective.

As has been noted, and as is recommended in the revised SNA, much of the statistical information in the satellite accounts will be measured in physical units rather than or as well as in monetary terms. In most cases, physical measurement of stocks and flows is a necessary first step even if the ultimate objective is monetary values. The measurement of physical stocks and flows is also less controversial. Some priority is being given to assessing monetary values for natural resource assets, but this effort is regarded as experimental at this stage. Like other countries, Canada is hoping a clearer international consensus on what valuation techniques are most appropriate will soon begin to emerge. The assignment of monetary values to natural resource assets will have the obvious benefit of facilitating aggregation and comparisons of diverse asset types.

In some areas the development work is moderately well advanced while in others little progress has been made so far beyond basic exploratory investigations. Canada's natural resources are vast and the task of building the satellite accounts is expected to take several years.

Conclusion

Canada's environmental statistics program has grown and matured considerably over the past two decades. Progress has been made on many fronts.

Four editions of the compendium ***Human Activity and the Environment*** have been published - in 1978, 1986, 1991 and 1994 - and each one has brought important extensions and improvements. The GIS-type environmental database upon which ***Human Activity and the Environment*** is built has grown larger and more comprehensive over time and this database is now available for use by the general public. The annual publication ***Environmental Perspectives: Studies and Statistics*** has been established to report on new developments in environmental statistics between the normally quinquennial issues of ***Human Activity and the Environment***.

Year by year, new environmental data sources have been developed. Some of these sources are the result of efforts to recast existing Statistics Canada survey data in ways that are more useful for environmental analysis. Others reflect the establishment of new household, business and government surveys designed to fill key data gaps. Still others arise from the identification and exploitation of administrative and regulatory data. And finally, in some cases new time series estimates are now being derived for the purposes of the environmental accounts by applying technical coefficients to economic data.[1]

Much headway has been made in developing an appropriate conceptual framework for environmental statistics, starting with the STRESS approach and evolving from there to the PEP system. Now, working with other countries and some international institutions, Canada is developing another framework, building upon the System of National Accounts structure that has proven so effective, for some fifty years, as a means for organizing economic statistics.

But the environmental statistics program still faces many important challenges as the demand for more and better statistics grows steadily. A great many data gaps remain and more new surveys are required. Despite the advances that have been made, there continues to be a vast potential for the better use of administrative and regulatory information for statistical purposes. The field of environmental accounting, while exciting and promising, is still in its infancy. Quite clearly, the future agenda for Canada's environmental statistics program is a full and challenging one.

References

Environment Canada, 1992, ***Water Use in Canadian Industry, 1986***, Economics and Conservation Branch, Minister of Supply and Services Canada, Ottawa.

_____, 1993, ***The Importance of Wildlife to Canadians: Highlights of the 1991 Survey***, Canadian Wildlife Service, Minister of Supply and Services Canada, Ottawa.

_____ and Statistics Canada, 1986, ***State of the Environment Report for Canada***, Minister of Supply and Services Canada, Ottawa.

Friend, Anthony, 1981, "Conceptual Frameworks and a Unified Approach to Environmental Statistics," ***Canadian Statistical Review***, Statistics Canada Cat. No. 11-003E.

_____ and David Rapport, 1979, ***Towards a Comprehensive Framework for Environmental Statistics: A Stress-Response Approach***, Statistics Canada Cat. No. 11-510.

1. For example, annual time series estimates of industrial greenhouse gas emissions, by type of gas, have been developed by applying engineering coefficients to input-output statistics. See R. Smith, Statistics Canada, 1993a, p. 9-18.

Government of Canada, 1990, ***Canada's Green Plan for a Healthy Environment***, Minister of Supply and Services Canada, Ottawa.

_____, 1991, ***The State of Canada's Environment***, Minister of Supply and Services Canada, Ottawa.

Gravel, Gerard, 1993, "Les Comptes Canadiens de l'Environnement et des Ressources Naturelles," paper presented to a symposium on national accounting, Université de Paris and l'Institut National de la Statistique et des Études Économiques, Paris.

Hamilton, Kirk E., 1988, "Energy Intensiveness and Economic Performance Since 1971", ***Canadian Economic Observer***, Statistics Canada Cat. No. 11-010, 1 (12).

Mitchell, Bruce W. and Kirk Hamilton, 1990, "Environmental Statistics at Statistics Canada," ***The Operational Geographer***, 8 (4): 33-43.

Moll, Richard H. H., 1992, "A Prototype Forest Resource Accounting System for Ontario: Concepts and Methods," ***Optimum***, 23 (3): 78-87.

Smith, Philip M., 1994, "The Canadian National Accounts Environmental Component: A Status Report," ***National Income and Expenditure Accounts, Annual Estimates, 1982-1993***, Statistics Canada Cat. No. 13-201.

Statistics Canada, 1978, ***Human Activity and the Environment***, Cat. No. 11-509E.

_____, 1986, ***Human Activity and the Environment***, Cat. No. 11-509E.

_____, 1989, ***A User Guide to the Canadian System of National Accounts***, Cat. No. 13-589E.

_____, 1991, ***Human Activity and the Environment 1991***, Cat. No. 11-509E.

_____, 1992a, ***Analysis of the Pollution Abatement and Control Survey***, uncatalogued.

_____, 1992b, ***Databases for Environmental Analysis: Government of Canada***, Cat. No. 11-527E.

_____, 1992c, ***1989 Waste Management Survey: A Pilot Enquiry***, uncatalogued.

_____, 1993a, ***Environmental Perspectives 1993: Studies and Statistics***, Cat. No. 11-528E.

_____, 1993b, ***The Input-Output Structure of the Canadian Economy***, 1990, Cat. No. 15-201.

_____, 1994a, ***Databases for Environmental Analysis: Provincial and Territorial Governments***, Cat. No. 11-529E.

_____, 1994b, ***Households and the Environment 1994***, Cat. No. 11-526.

_____, 1994c, ***Human Activity and the Environment 1994***, Cat. No. 11-509E.

_____, 1994d, ***National Balance Sheet Accounts, 1984-1993***, Cat. No. 13-214.

United Nations, 1993a, ***SNA Handbook on Integrated Environmental and Economic Accounting***, Statistical Office of the United Nations, Series F#61, New York.

_____, 1993b, Commission of the European Communities-Eurostat, International Monetary Fund, Organization for Economic Co-operation and Development and World Bank, ***System of National Accounts***, ST/ESA/STAT/SER.F/2/Rev.4, New York.

2 Environmental Change Around Waterton Lakes National Park

by Douglas Trant[1], Christine de Boer[1] and Kevin Van Tighem[2]

Introduction

Waterton Lakes National Park is part of the Crown of the Continent ecosystem. This ecosystem is centred around the Lewis, Clark and Livingston Ranges of the Rocky Mountains and covers 15 000 square kilometres of southwestern Alberta and southeastern British Columbia in Canada, and northwestern Montana in the United States. Map 2.1 indicates the location of the study area.

Map 2.1
Study Area Location

Waterton Lakes National Park is part of the protected core of the Crown and is known as the place "...where prairie grasslands meet the Rocky Mountains." In fact, the entire area is one of abrupt landscape transitions. Because of the exceptional biodiversity and cultural value of the area, the Man and the Biosphere Program, initiated by the United Nations Educational, Scientific and Cultural Organization (UNESCO), designated Waterton Lakes National Park as a "biosphere reserve" in 1976. This serves to encourage the protection and scientific study of this area for all the world's people.[3]

Waterton Lakes National Park has both intrinsic and scientific value. On the one hand, it is a Canadian national park, a place that has been set aside to be kept unimpaired and in a state of ecological integrity so as to benefit present and future generations of Canadians. On the other hand, as a biosphere reserve it is the protected core of a diverse and important regional ecosystem and serves as a benchmark for measuring the impacts of change in that broader area.

The present study was undertaken as part of a broad initiative to detect trends and emerging issues within the Crown of the Continent ecosystem. The scenic beauty, abundant wildlife and ecological diversity that most residents and visitors consider to characterize the Crown are all influenced by social and economic factors that lead to landscape modification or changing levels and intensities of human use. The purpose of this study is to measure changing socio-economic trends that are influencing the environment within the Crown of the Continent ecosystem.

Physiography of the study area

The study area is formed by four areas which can be described by the characteristics of the ecoregions which are contained within them. Demarchi and Lea (1993) describe these ecoregions, which are depicted in Map 2.2, in detail.

The Flathead Trench, the Rocky Mountains and higher portions of the Porcupine Hills are within the Northern Continental Divide ecoregion. For the purposes of this study, this ecoregion is divided into two areas between British Columbia and Alberta. This ecoregion is characterized by coniferous forest ranging from Douglas-fir and limber pine at lower elevations, through extensive lodgepole pine forests to high elevation forests of subalpine fir, Engelmann spruce and whitebark pine. The climate here is Cordilleran with mild summers (less than 80 frost-free days per year) and cold winters frequently moderated by mild chinook winds. Annual precipitation exceeds 400 mm with most falling between May and July.

In the Chinook Upland ecoregion, the foothills and lower portions of the Porcupine Hills are found. This area is characterized by the prevalence of rough fescue/timer oatgrass grassland in a rolling upland landscape and some extensive stands of aspen. The climate is predominantly continental with warm summers (80 to 100 frost-free days per year) and cold winters frequently moderated by mild chinook winds. Annual levels of precipitation are between 450 and 600 mm, with peak rainfall between May and July.

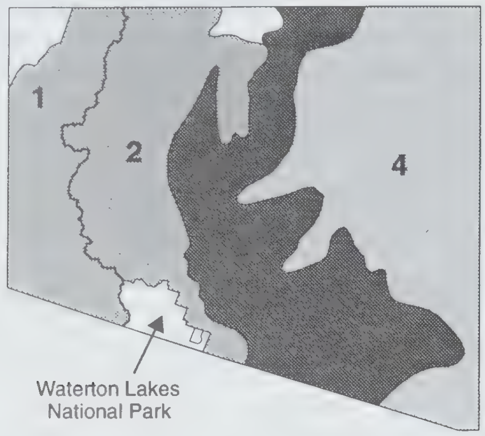
The third ecoregion within the study area is the Southern Alberta Plains, which includes the western edge of the Great

1. Research Analysts, National Accounts and Environment Division, Statistics Canada, Ottawa, Ontario.
2. Ecosystem Management Specialist, Waterton Lakes National Park, Waterton Park, Alberta.

3. To date, six UNESCO biosphere reserves have been designated in Canada, while more than 300 other heritage sites have been chosen in the 198 bio-geographic provinces around the world.

Map 2.2

Ecoregion Study Area Reference Map - Province and Ecoregion Boundaries



Provincial Ecoregions:

BRITISH COLUMBIA

1 - Northern Continental Divide

ALBERTA

2 - Northern Continental Divide
3 - Chinook Upland
4 - Southern Alberta Plains

Source:
Demarchi, D.A. and E.C. Lea, 1993.

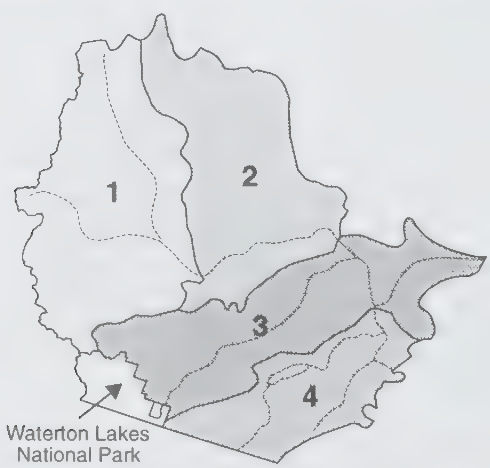
Plains and the downstream reaches of major rivers draining the east side of the Crown of the Continent ecosystem. This area is characterized by the prevalence of speargrass/wheatgrass grassland in an undulating plain with deeply incised river valleys. However much of the natural vegetation has been converted to agricultural uses. The climate here is continental with hot summers (100 to 120 frost-free days per year) and cold winters occasionally moderated by chinook winds. Annual precipitation averages from 350 to 500 mm, with most falling from May through July.

A second perspective for this study was to examine changing land use within watersheds surrounding Waterton Lakes National Park. There are four river basins which are studied, where the western edge of the Great Plains, incised by coulees and large river valleys, ranges in elevation from 3 000 to 4 500 feet. Map 2.3 defines this study area and indicates the park's location. Major drainage basins include the Upper Oldman River, Willow Creek, Belly, Waterton and St. Mary Rivers.

For the purposes of this study, socioeconomic and land data are stratified and analyzed by ecoregion, as defined by the ecoregion study area, and by watershed, as defined by the river basin study area.

Map 2.3

River Basin Study Area Reference Map - River Basin Boundaries



River Basins:

ALBERTA

1 - Upper Oldman River Basin
2 - Willow Creek Basin
3 - Belly and Waterton Rivers Basin
4 - St. Mary River Basin

—— river basin boundaries

—— river

Note:
The solid lines represent river basin boundaries. Dashed lines indicate larger river channels only.
Source:
Water Resources Branch, Inland Waters Directorate, Environment Canada, 1986.

Employment and demographic trends

The Canadian portion of the Crown of the Continent ecosystem is sparsely populated, especially west of the Continental Divide. Population density increases eastward from the Rockies and land use is for the most part agricultural. The main agricultural activities include cattle/forage ranches and mixed barley and wheat farms.

Table 2.1 indicates that the population of the ecoregion study area increased by 34 percent between 1971 and 1991. The largest change occurred between 1971 and 1981 when population increased by 25 percent. In Table 2.2 rural population increased by 15 percent over the twenty year study period, and now exceeds a one-third share of the area's population. The largest fluctuations and changes in rural population occurred in the Northern Continental Divide ecoregion. In addition, the total population of this region more than doubled between 1971 and 1991.

Table 2.1

Population by Ecoregion, 1971 - 1991

Provincial ecoregion	Total population					Population change		
	1971	1976	1981	1986	1991	1971-1981	1981-1991	1971-1991
	number of people					percent		
British Columbia								
Northern Continental Divide	3 926	6 784	8 291	8 938	7 854	111.2	-5.3	100.1
Alberta								
Northern Continental Divide	7 807	8 650	8 879	8 368	8 022	13.7	-9.7	2.8
Chinook Upland	16 571	16 108	17 201	16 698	18 028	3.8	4.8	8.8
Southern Alberta Plains	72 428	82 254	91 856	97 210	100 806	26.8	9.7	39.2
Study area total	**100 732**	**113 796**	**126 227**	**131 214**	**134 710**	**25.3**	**6.7**	**33.7**

Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Table 2.2

Rural Population by Ecoregion, 1971 - 1991

Provincial ecoregion	Rural population					Population change			Rural share of total population		
	1971	1976	1981	1986	1991	1971-1981	1981-1991	1971-1991	1971	1981	1991
	number of people					percent			percent		
British Columbia											
Northern Continental Divide	1 773	1 796	1 898	3 233	2 455	7.1	29.3	38.5	45.2	22.9	31.3
Alberta											
Northern Continental Divide	2 994	3 600	4 287	5 064	4 773	43.2	11.3	59.4	38.4	48.3	59.5
Chinook Upland	10 659	9 617	10 177	9 401	10 888	-4.5	7.0	2.1	64.3	59.2	60.4
Southern Alberta Plains	17 000	19 550	19 576	19 788	19 271	15.2	-1.6	13.4	23.5	21.3	19.1
Study area total	**32 426**	**34 563**	**35 938**	**37 486**	**37 387**	**10.8**	**4.0**	**15.3**	**32.2**	**28.5**	**27.8**

Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

In addition to population size, employment statistics provide valuable insight into the economy of the area. Table 2.3 provides counts of the number of people employed by industry within each ecoregion for the years 1981 and 1991.

The Southern Alberta Plains ecoregion employment profile dominated the employment distribution figures in the study area as it supported 75 percent of the total employment. For this region, the services and trade industries together accounted for close to one half of employed persons. By 1991 employment had decreased in the trade, manufacturing and construction industries, while increases in employment occurred in the services and public administration industries.

Within the ecoregions, the ranking of industries by relative contribution to employment varied slightly. In the British Columbia Northern Continental Divide, the mining industry dominated the employment distribution with over half of this region's employment. This industry also maintained strong employment in the Alberta portion of the Northern Continental Divide over the ten years. This high proportion of mining activity is due to the existence of eleven open pit mines and one crushing plant in the Canadian portion of the Crown of the Continent ecosystem. The services industry was consistently among the top two industries in all ecoregions. Wholesale and retail trade were the third largest employer in the Northern Continental Divide and Chinook Upland regions. The agriculture industry dominated for both 1981 and 1991 in the Chinook Upland ecoregion, accounting for close to 30 percent of the area's employment. Although the manufacturing and agriculture industries alternated as the third largest employer in the Southern Alberta Plains between 1981 and 1991, both are still significant contributors to employment.

Despite consistent increases in the levels of employment between 1981 and 1991 in the Chinook Upland and Southern Alberta Plains ecoregions, the employment rate declined for the same period. The employment rates ranged from 91 percent to 95 percent in 1981, but by 1991 they had dropped to between 88 percent and 92 percent. During the same period, the size of the labour force grew by one quarter for the Chinook Upland ecoregion, while only small increases were felt in the Northern Continental Divide - an area which experienced both a decline in population and a reduction in labour force size between 1981 and 1991.

Table 2.3
Employment by Industry and Ecoregion, 1981 and 1991

	Ecoregion															
	B.C. - Northern Continental Divide				Alberta - Northern Continental Divide				Chinook Upland				Southern Alberta Plains			
	Employed persons		Employment distribution		Employed persons		Employment distribution		Employed persons		Employment distribution		Employed persons		Employment distribution	
Industry	1981	1991	1981	1991	1981	1991	1981	1991	1981	1991	1981	1991	1981	1991	1981	1991
	persons		percent		persons		percent		persons		percent		persons		percent	
Agriculture	25	40	0.6	1.2	350	340	9.4	9.3	1 925	2 660	28.7	32.6	4 320	4 555	10.1	9.9
Communication	45	35	1.1	1.0	50	45	1.3	1.3	65	35	1.0	0.5	850	825	2.0	1.8
Construction	250	105	6.5	2.8	255	190	6.8	5.3	550	515	8.2	6.3	3 610	2 595	8.5	5.7
Finance	60	125	1.6	3.4	120	105	3.1	2.9	160	170	2.4	2.1	1 810	1 715	4.2	3.7
Fishing and hunting	-	-	-	-	-	-	-	-	-	5	-	0.1	5	15	0.0	0.0
Forestry	40	10	1.0	0.4	70	80	2.0	2.1	20	25	0.2	0.3	5	40	0.0	0.1
Manufacturing	160	115	4.1	3.1	315	280	8.4	7.6	280	285	4.2	3.5	4 800	3 940	11.2	8.6
Mining	2 155	1 845	55.8	50.3	815	660	21.8	18.1	270	225	4.1	2.7	195	320	0.5	0.7
Public administration	90	130	2.4	3.5	210	225	5.6	6.1	450	550	6.7	6.7	3 305	3 765	7.7	8.2
Public utilities	-	25	-	0.7	20	30	-	0.8	55	45	0.9	0.5	530	520	1.2	1.1
Services	640	700	16.5	19.0	825	1 005	22.1	27.5	1 420	2 200	21.2	26.9	11 845	16 645	27.7	36.3
Transport and storage	140	95	3.6	2.5	70	100	1.9	2.7	175	215	2.6	2.6	1 715	1 950	4.0	4.2
Wholesale and retail trade	240	375	6.2	10.2	515	495	13.9	13.6	960	980	14.3	11.9	8 585	7 920	20.1	17.3
Undefined	40	75	1.0	2.0	120	100	3.3	2.7	385	260	5.7	3.2	1 185	1 075	2.8	2.3
Total employed	**3 870**	**3 665**	**100.0**	**100.0**	**3 740**	**3 645**	**100.0**	**100.0**	**6 705**	**8 170**	**100.0**	**100.0**	**42 740**	**45 895**	**100.0**	**100.0**
Total unemployed	**290**	**500**	...	...	**370**	**515**	...	...	**380**	**735**	...	...	**2 860**	**5 465**	...	...
Total labour force[1]	**4 165**	**4 175**	...	...	**4 105**	**4 165**	...	...	**7 095**	**8 905**	...	...	**45 600**	**51 370**	...	...

Notes:
Figures may not add due to rounding.
1. Total labour force data is the sum of employed and unemployed persons.
Sources:
Statistics Canada, National Accounts and Environment Division and Census of Population.

Land use characteristics

Agriculture is the dominant land use activity in the ecoregion study area. Throughout the study period (1971-1991) agriculture has occupied on average between 61 and 67 percent of the land area here. Farmland area increased by 8.8 percent over the 20 year period rising from 1.48 to 1.61 million hectares. Table 2.4 describes these changes in farmland area in absolute and relative terms.

The principal ecoregion undergoing change is the Northern Continental Divide. Here the amount of farmland area within the Alberta portion tripled by 1991, though farmland still accounts for less than 50 percent of the ecoregion area. The British Columbia portion of the Northern Continental Divide has experienced a 25 percent reduction in farmland. Little change has occurred in the Southern Alberta Plains and the Chinook Upland which consist mainly of farmland (90 percent).

Table 2.5 looks at farmland area in the river basin study area. Here farmland occupies an average of 61 percent of the land area, with only a marginal increase in area between 1971 and 1991. Moderate decreases in farmland area occurred in the Willow Creek and Belly/Waterton River basins.

Table 2.4
Farmland Area by Ecoregion, 1971 - 1991

Provincial ecoregion	Ecoregion area	Farmland area 1971	1976	1981	1986	1991	Proportion in agriculture 1971	1991	Change in area 1971-1981	1981-1991	1971-1991
	hectares						percent				
British Columbia											
Northern Continental Divide	339 991	3 995	3 922	3 510	3 871	2 973	1.2	0.9	-12.1	-15.3	-25.6
Alberta											
Northern Continental Divide	543 336	78 173	126 162	125 150	138 503	241 183	14.4	44.4	60.1	92.7	208.5
Chinook Upland	714 851	647 460	555 062	557 977	561 639	649 157	90.6	90.8	-13.8	16.3	0.3
Southern Alberta Plains	819 159	752 674	827 655	770 746	763 127	719 940	91.9	87.9	2.4	-6.6	-4.3
Study area total	**2 417 337**	**1 482 302**	**1 512 801**	**1 457 383**	**1 467 140**	**1 613 253**	**61.3**	**66.7**	**-1.7**	**10.7**	**8.8**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.5
Farmland Area by River Basin, 1971 - 1991

River basin	River basin area	Farmland area 1971	1976	1981	1986	1991	Proportion in agriculture 1971	1991	Change in area 1971-1981	1981-1991	1971-1991
	hectares						percent				
Willow Creek	416 210	270 621	262 601	250 952	253 931	239 244	65.0	57.5	-7.3	-4.7	-11.6
Upper Oldman River	494 237	179 285	218 225	212 280	207 286	262 757	36.3	53.2	18.4	23.8	46.6
Belly/Waterton Rivers	446 086	337 047	331 322	301 726	311 961	257 321	75.6	57.7	-10.5	-14.7	-23.7
St. Mary River	233 311	168 323	184 561	187 337	194 076	208 715	72.1	89.5	11.3	11.4	24.0
Total[1]	**1 589 844**	**955 276**	**996 709**	**952 295**	**967 254**	**968 037**	**60.1**	**60.9**	**-0.3**	**1.7**	**1.3**

Note:
1. This total is the sum of the four river basins and does not equal the total presented in the ecoregion summaries.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Over the twenty year period, the average farm size in the ecoregion study area increased by almost 10 percent to reach 460 hectares. This farm size was 26 percent larger than the Alberta average of 364 hectares in 1991.[1]

Table 2.6 shows that the greatest change in farm numbers and average size occurred in the Northern Continental Divide. Average farm size decreased within British Columbia's portion of this ecoregion as a result of a reduction in farmland area and an increase in farm numbers. In the Alberta portion, however, there was a greater farmland area and more farms by 1991, increasing the average farm size by 12 percent in Alberta's Northern Continental Divide. The only ecoregion to experience both a reduction in farmland area and farm numbers by 1991 was the Southern Alberta Plains, though steady increases in average farm size occurred throughout the study period.

In the river basin study area, farm numbers decreased by 9 percent and average farm size increased by close to 3 percent overall. Both the Willow Creek and Belly/Waterton River basins saw reductions in farmland area and the number of farms.

1. Statistics Canada, 1992, p. 53.

Table 2.6
Number of Farms and Farm Size by Ecoregion, 1971 - 1991

Provincial ecoregion	Number of farms 1971	1976	1981	1986	1991	Change 1971-1991	Average farm size 1971	1981	1991	Change 1971-1991
						percent	hectares per farm			percent
British Columbia										
Northern Continental Divide	21	28	37	38	35	66.7	190	95	85	-55.4
Alberta										
Northern Continental Divide	164	216	229	230	270	64.6	477	547	893	87.4
Chinook Upland	1 084	1 051	1 067	1 067	1 259	16.1	597	523	516	-13.7
Southern Alberta Plains	2 276	2 269	2 106	2 176	1 946	-14.5	331	366	370	11.9
Study area total	**3 545**	**3 564**	**3 439**	**3 511**	**3 510**	**-1.0**	**418**	**424**	**460**	**9.9**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.7
Number of Farms and Farm Size by River Basin, 1971 - 1991

River basin	Number of farms 1971	1976	1981	1986	1991	Change 1971-1991	Average farm size 1971	1981	1991	Change 1971-1991
						percent	hectares per farm			percent
Willow Creek	505	471	493	544	475	-5.9	536	533	485	-9.4
Upper Oldman River	330	337	349	359	336	1.8	543	630	753	38.6
Belly/Waterton Rivers	1 146	1 160	1 092	1 122	958	-16.4	294	260	236	-19.9
St. Mary River	437	430	455	483	424	-3.0	385	436	459	19.1
Total[1]	**2 418**	**2 398**	**2 389**	**2 508**	**2 193**	**-9.3**	**395**	**397**	**405**	**2.6**

Note:
1. This total is the sum of the four river basins and does not equal the total presented in the ecoregion summaries.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Tables 2.8 and 2.9 look at the "Improved farmland"[1] trends around the park. In the ecoregion study area cropland increased by 42 percent, with the largest change occurring in the Chinook Upland. In the river basin study area, an overall increase of 28 percent in cropland area occurred, with the St. Mary River basin almost doubling its share.

Large reductions in summerfallow were evident in all areas. Such reductions in summerfallow can be regarded as positive in that they reduce the risk of soil salinization.[2]

1. **Improved farmland** is defined here to include cropland, improved pasture and summerfallow. "Other" land categorized as improved farmland which have been omitted from this study include woodland, idle land, barnyards and laneways.
2. Dumanski, J. *et al.*, 1986, p. 206.

Improved pasture increased by 15 percent in the ecoregion study area, with the Northern Continental Divide more than tripling its share. Among the four river basins an overall reduction of 6 percent in improved pasture occurred, with the only increase occurring in the Upper Oldman River area.

New farmland area usually originates from land that was once natural habitat. In this region of Canada newly acquired lands are generally referred to as unimproved farmland and are primarily used for cattle grazing.

Table 2.8

Improved Farmland by Ecoregion, 1971-1991

	Cropland				Improved pasture				Summerfallow			
Provincial ecoregion	1971	1981	1991	Change 1971-1991	1971	1981	1991	Change 1971-1991	1971	1981	1991	Change 1971-1991
	hectares			percent	hectares			percent	hectares			percent
British Columbia												
Northern Continental Divide	663	918	735	10.9	32	420	489	1 428.1	x	x	x	x
Alberta												
Northern Continental Divide	14 623	20 487	22 525	54.0	2 942	7 407	10 553	258.7	3 003 [1]	1 604 [1]	2 058 [1]	-31.5
Chinook Upland	154 834	225 250	293 581	89.6	32 333	42 367	37 614	16.3	52 811	24 067	14 917	-71.8
Southern Alberta Plains	332 584	417 716	395 239	18.8	48 859	52 834	47 894	-2.0	178 824	111 671	108 681	-39.2
Study area total	**502 704**	**664 372**	**712 080**	**41.7**	**84 165**	**103 027**	**96 550**	**14.7**	**234 638**	**137 342**	**125 656**	**-46.5**

Notes:
Figures may not add due to rounding.
1. Data for the Alberta and British Columbia portions of the Northern Continental Divide have been combined to preserve confidentiality.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.9

Improved Farmland by River Basin, 1971-1991

	Cropland				Improved pasture				Summerfallow			
River basin	1971	1981	1991	Change 1971-1991	1971	1981	1991	Change 1971-1991	1971	1981	1991	Change 1971-1991
	hectares			percent	hectares			percent	hectares			percent
Willow Creek	67 054	102 191	85 551	27.6	19 817	24 544	18 974	-4.3	31 612	21 429	11 674	-63.1
Upper Oldman River	35 748	48 013	33 601	-6.0	5 998	13 053	10 633	77.3	10 785	3 843	2 252	-79.1
Belly/Waterton Rivers	126 567	151 184	124 821	-1.4	19 475	20 313	16 818	-13.6	47 835	23 497	10 044	-79.0
St. Mary River	76 384	119 270	145 939	91.1	14 889	15 033	10 264	-31.1	28 726	6 933	5 031	-82.5
Total[1]	**305 753**	**420 657**	**389 913**	**27.5**	**60 180**	**72 943**	**56 689**	**-5.8**	**118 957**	**55 702**	**29 001**	**-75.6**

Note:
1. This total is the sum of the four river basins and does not equal the total presented in the ecoregion summaries.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

In the ecoregion study area, the amount of unimproved farmland increased by 3 percent, increasing its proportion of the ecoregion area to 28 percent (see Table 2.10). Most of the increase occurred in the Northern Continental Divide where new areas of rangeland have been opened up. The greatest change was in the Alberta portion of this region, where the unimproved farmland area more than tripled.

In the river basin study area, there was a total increase of 5 percent in unimproved farmland area. The Upper Oldman River basin accounted for the majority of this change with an increase of 71 percent. The Willow Creek and Belly/Waterton River basins experienced moderate declines in unimproved area with 19 and 26 percent reductions respectively. These figures are listed in Table 2.11.

Agricultural practices and their effects

The Crown of the Continent ecosystem is subject to environmental modification from a number of sources. The sources measured in this study include pesticide use and irrigation.

In landscapes with high ecological integrity, nutrients are cycled internally within diverse natural ecosystems. A simple analogy might be to compare a suburban lawn with adjacent native prairie.

The suburban lawn is a simple ecosystem containing perhaps ten species of plants, and is consequently subject to constant invasion by weed species which are usually con-

Table 2.10
Unimproved Farmland by Ecoregion, 1971-1991

Provincial ecoregion	Ecoregion area	Unimproved farmland area 1971	1981	1991	Proportion of unimproved farmland 1971	1991	Change in unimproved farmland area 1971-1981	1981-1991	1971-1991
	hectares				percent				
British Columbia									
Northern Continental Divide	339 991	3 269	2 078	1 749	1.0	0.5	-36.4	-15.9	-46.5
Alberta									
Northern Continental Divide	543 336	57 605	95 652	206 046	10.6	37.9	66.0	115.4	257.7
Chinook Upland	714 851	407 482	266 293	303 046	57.0	42.4	-34.6	13.8	-25.6
Southern Alberta Plains	819 158	192 407	188 525	168 126	23.5	20.5	-2.0	-10.8	-12.6
Study area total	**2 417 336**	**660 764**	**552 549**	**678 967**	**27.3**	**28.1**	**-16.4**	**22.9**	**2.8**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.11
Unimproved Farmland Around Waterton Lakes National Park by River Basin, 1971-1991

River basin	River basin area	Unimproved farmland area[1] 1971	1981	1991	Proportion of unimproved farmland 1971	1991	Change in unimproved farmland area 1971-1981	1981-1991	1971-1991
	hectares				percent				
Willow Creek	416 210	152 139	102 789	123 045	36.6	29.6	-32.4	19.7	-19.1
Upper Oldman River	494 237	126 755	147 372	216 271	25.6	43.8	16.3	46.8	70.6
Belly/Waterton Rivers	446 086	143 170	106 733	105 638	32.1	23.7	-25.5	-1.0	-26.2
St. Mary River	233 311	48 324	46 101	47 481	20.7	20.4	-4.6	3.0	-1.7
Total[2]	**1 589 844**	**470 388**	**402 994**	**492 436**	**29.6**	**31.0**	**-14.3**	**22.2**	**4.7**

Notes:
1. Unimproved farmland areas are calculated using total farmland values and the sum of improved land variables listed in Table 9.
2. This total is the sum of the four river basins and does not equal the total represented in the ecoregion summaries.

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

trolled by herbicides. It requires regular fertilization to replace lost nutrients, frequent watering because the species present are not adapted to the local climate, and lawn mowing substitutes for the cropping action of herbivores. Inputs of energy, pesticides and water are high.

The adjacent native prairie, on the other hand, is cropped by cattle or wild ungulates with the nutrients removed by cropping being recycled as dung. There may be more than 50 different plants, including weeds, interacting seasonally and continually replenishing the soil, and capable of thriving with the water that is available from rain and snow.

Based on this analogy, it can be seen that application rates of fertilizers, herbicides, insecticides and water can serve as one indicator of ecosystem function; the higher the quantities used, the more artificial inputs are substituting for the self-regenerative capabilities of healthy ecosystems. Fertilizers represent lost soil fertility, pesticides represent simplified and unstable ecosystems, and irrigation represents a de-coupling of plant communities from the regional climate.

The use of pesticides also can be seen as an indicator of environmental stress, since runoff of fertilizers and pesticides has been associated with water degradation, and since some pesticides are persistent and bioaccumulate in plants and animals.

Pesticide expenditures in the Waterton Lakes area more than tripled since 1970.[1] These values are shown in Tables 2.12 and 2.13. In the ecoregion study area, the rate of application per hectare of cultivated land[2] increased from \$2.86 to \$10.84 constant 1990 dollars. Though this is a large increase, the average value reached in 1990 was 46 percent below the national average of \$15.80 per hectare.[3]

1. Value of pesticide applied is only a surrogate for actual change in pesticide toxicity.
2. Cultivated land includes cropland, improved pasture and summerfallow areas.
3. Statistics Canada, 1994, p. 20.

Table 2.12
Agricultural Chemical Expenditures and Application Rates by Ecoregion, 1970-1990

Provincial ecoregion	Agricultural chemical expenditures 1970	1980	1990	Change 1970-1990	Cultivated land area 1970	1980	1990	Change 1970-1990	Value of chemical per hectare of cultivated land 1970	1980	1990	Change 1970-1990
	1990 dollars			percent	hectares			percent	1990$/hectare			percent
Northern Continental Divide[1]	18 598	68 838	104 520	462.0	21 294	30 930	36 361	70.8	0.87	2.23	2.87	229.1
Chinook Upland	563 867	2 290 425	3 587 124	536.2	239 978	291 684	346 112	44.2	2.35	7.85	10.36	341.1
Southern Alberta Plains	1 764 684	4 722 156	6 434 354	264.6	560 267	582 221	551 814	-1.5	3.15	8.11	11.66	270.2
Study area total	**2 347 149**	**7 081 419**	**10 125 998**	**331.4**	**821 538**	**904 835**	**934 287**	**13.7**	**2.86**	**7.83**	**10.84**	**279.4**

Notes:
Chemical dollar values have been deflated by using farm input price indices for 1970-1990.
1. For the purposes of this table data for the Alberta and British Columbia portions of the Northern Continental Divide have been combined to preserve confidentiality.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.13
Agricultural Chemical Expenditures and Application Rates by River Basin, 1970-1990

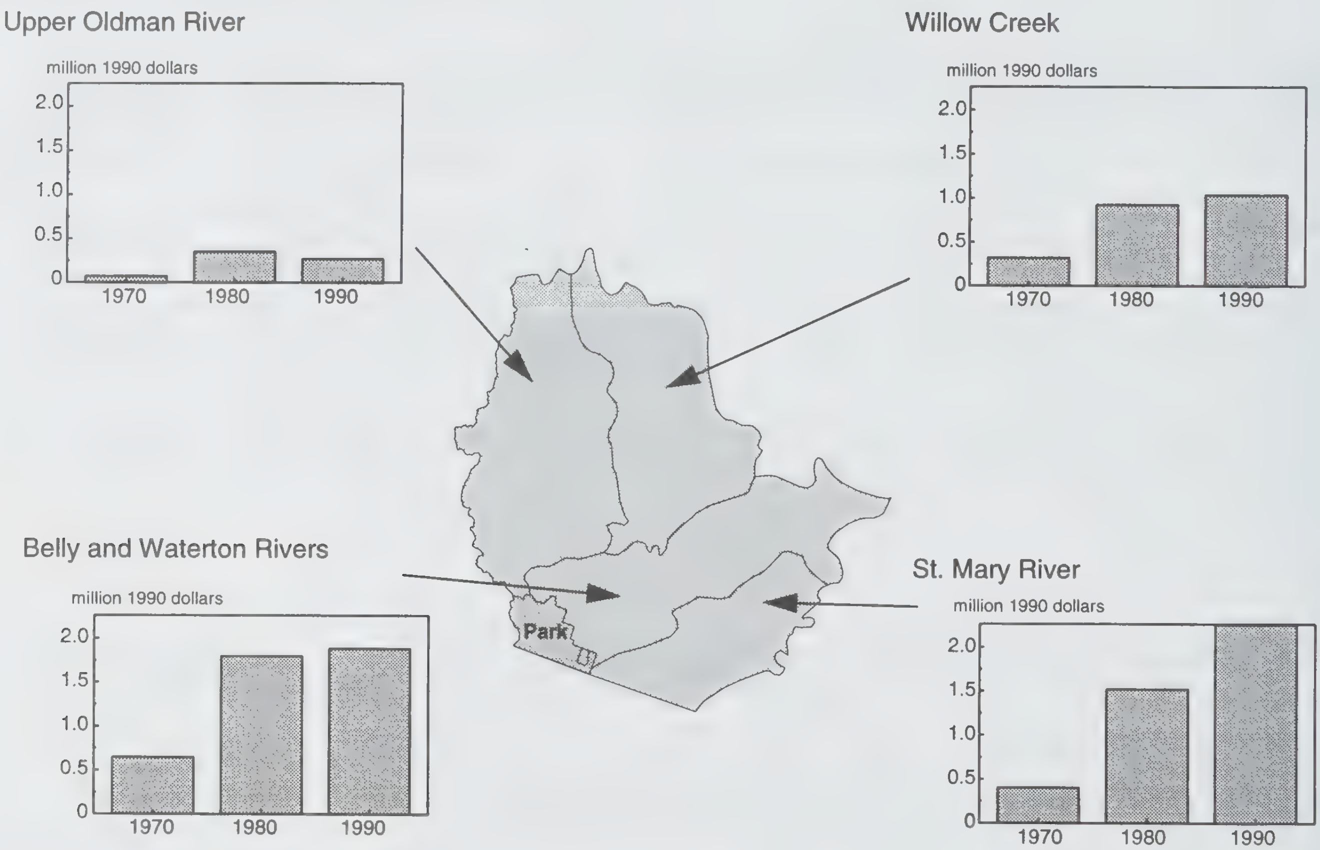
River basin	Agricultural chemical expenditures 1970	1980	1990	Change 1970-1990	Cultivated land area 1970	1980	1990	Change 1970-1990	Value of chemical per hectare of cultivated land 1970	1980	1990	Change 1970-1990
	1990 dollars			percent	hectares			percent	1990$/hectare			percent
Willow Creek	319 763	925 007	1 034 557	223.5	118 483	148 163	116 199	-1.9	2.70	6.24	8.90	229.9
Upper Oldman River	72 839	355 169	270 896	271.9	52 531	64 909	46 486	-11.5	1.39	5.47	5.83	320.3
Belly/Waterton Rivers	646 679	1 798 309	1 883 949	191.3	193 877	194 994	151 683	-21.8	3.34	9.22	12.42	272.4
St. Mary River	400 531	1 520 257	2 255 449	463.1	119 999	141 236	161 234	34.4	3.34	10.76	13.99	319.1
Total[1]	**1 439 812**	**4 598 742**	**5 444 851**	**278.2**	**484 890**	**549 302**	**475 603**	**-1.9**	**2.97**	**8.37**	**11.45**	**285.5**

Notes:
Chemical dollar values have been deflated by using farm input price indices for 1970-1990.
1. This total is the sum of the four river basins and does not equal the total represented in the ecoregion summaries.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

In the river basin study area, the St. Mary River basin was the only area which incurred an increase in cultivated land area. The overall pesticide value per hectare reached $11.45 in 1990.

The bar graphs in Figure 2.1 indicate the trends in pesticide expenditures for each of the four river basins. Here we see a greater increase in the use of pesticides occurring between 1970 and 1980, with slight increases by 1990. In the Upper Oldman River Basin, however, pesticide expenditures actually declined between 1980 and 1990, though the final level reached was still more than three times the value of pesticides originally purchased in 1970.

Figure 2.1
Pesticide Expenditures by River Basin for 1970 - 1990



Sources:
Statistics Canada, National Accounts and Environment Division and Census of Agriculture.

The application of pesticides is needed to control both insects and weeds from invading cultivated land. As evident in Tables 2.14 and 2.15, the land area to which both insecticides and herbicides are being applied has increased dramatically since 1970.

Among the river basins, the greatest increases of cultivated land area treated with pesticides were in the St. Mary River basin. Here, more than a seven-fold increase occurred in the area sprayed for insects, while the area sprayed for weeds more than tripled.

Greater amounts of pesticide are being applied to the east of Waterton Lakes National Park, specifically within the Belly/Waterton Rivers and St. Mary River basins. These areas also support the bulk of irrigated agriculture in the study area and have by far the greatest acreage under cultivation in cropland (Table 2.9).

Table 2.14
Areas Sprayed With Insecticides and Herbicides by Ecoregion, 1970-1990

	Area sprayed for insects				Area sprayed for weeds			
Provincial ecoregion	1970	1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990
	hectares			percent	hectares			percent
Northern Continental Divide[1]	69	20	245	255.9	2 216	6 317	5 348	141.3
Chinook Upland	2 891	1 838	26 113	803.1	57 838	157 612	199 294	244.6
Southern Alberta Plains	8 849	8 131	42 471	379.9	143 458	299 773	301 247	110.0
Study area total	**11 810**	**9 989**	**68 829**	**482.8**	**203 513**	**463 703**	**505 889**	**148.6**

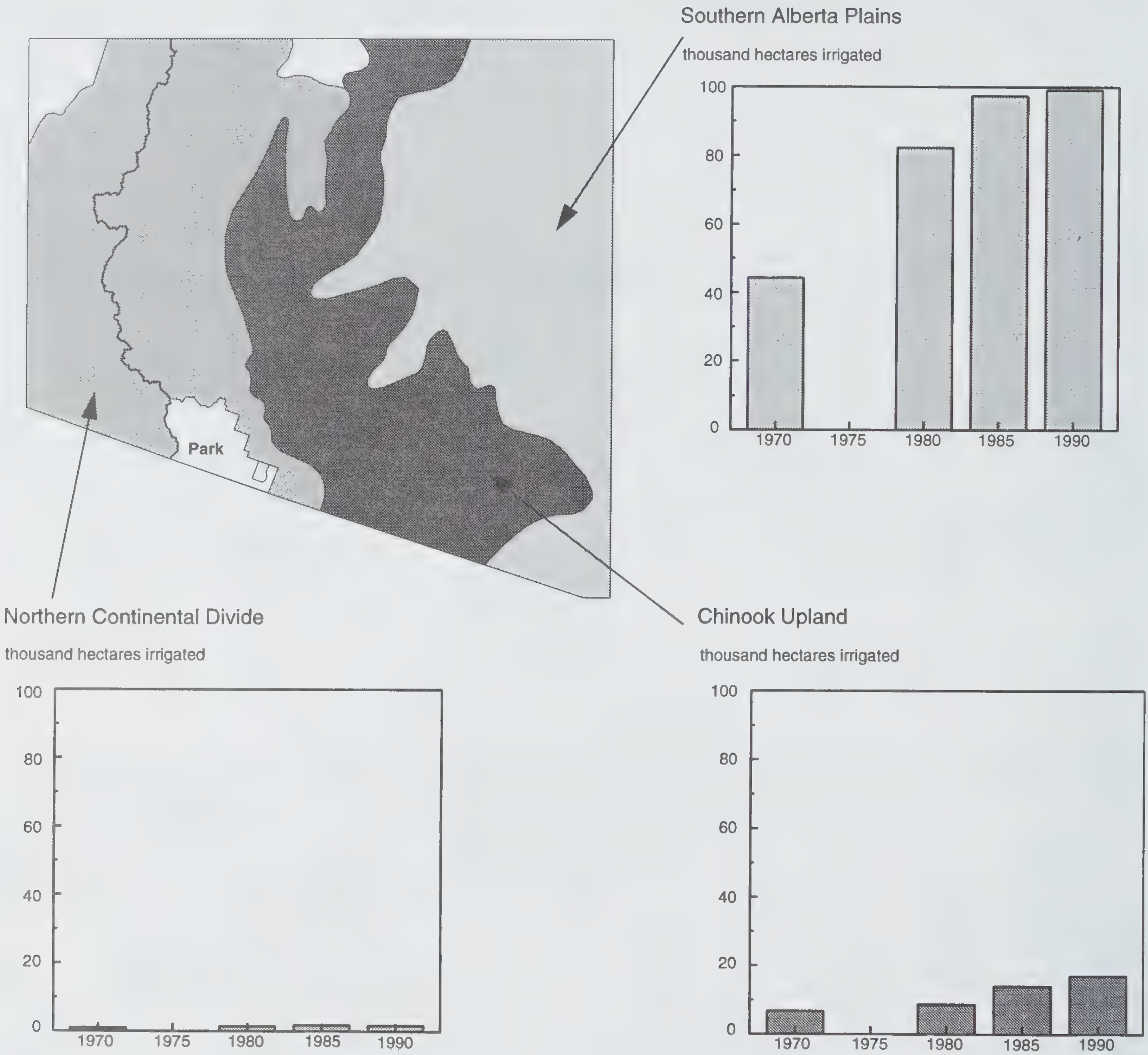
Note:
1. For purposes of this table data for the Alberta and British Columbia portions of the Northern Continental Divide have been combined to preserve confidentiality.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.15
Areas Sprayed With Insecticides and Herbicides by River Basin, 1970-1990

	Area sprayed for insects				Area sprayed for weeds			
River basin		1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990
	hectares			percent	hectares			percent
Willow Creek	1 889	1 336	5 915	213.1	25 400	67 822	56 002	120.5
Upper Oldman River	184	75	639	246.8	10 756	26 327	12 305	14.4
Belly River	3 565	2 291	11 464	221.5	52 094	97 029	79 270	52.2
St. Mary River	2 085	670	15 482	642.5	34 167	94 308	110 864	224.5
Total[1]	**7 724**	**4 372**	**33 499**	**333.7**	**122 418**	**285 487**	**258 442**	**111.1**

Note:
1. This total is the sum of the four river basins and does not equal the total represented in the ecoregion summaries.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 2.2
Irrigated Area by Ecoregion, 1970 - 1990



Source:
Demarchi, D.A. and E.C. Lea, 1993.

Irrigation is another agricultural practice with significant economic benefits and considerable environmental impact. The availability of irrigation water allows more intensive agriculture by stabilizing and maximizing yields and enabling farmers to grow a greater variety of crops than might otherwise be the case.

Irrigation development in the area surrounding Waterton Lakes National Park dates back to the late 1800's when Mormons began diverting water from Lee Creek, a tributary of the St. Mary River, to irrigate farmland in the Cardston area. Since then, all rivers in the Alberta portion of the study area have been developed for irrigation. Major projects have included the St. Mary Dam (1951), the Waterton River Dam (1964), the Oldman River Dam (1992) and three diversion weirs on the Belly River.

Irrigation can also have positive effects. It increases vegetation diversity by allowing the establishment of poplar, willow and other species along canals and in upland areas. At the same time it can be detrimental to ecosystem health if too much water is removed from streams during critical periods, or if on-stream dams interrupt hydrological processes that sustain downstream ecosystems. Rood (1987) documented a 25 percent decline in cottonwood forests - which rely on regular spring flooding and adequate summer water levels - downstream of the Waterton River Dam, and a 55 percent decline downstream from the St. Mary River Dam.

Ecological diversity is far higher in areas adjacent to water than elsewhere in the Southern Alberta Plains ecoregion (World Wildlife Fund Canada, 1989). In the prairie regions of Canada, forests located near water are important corridors that allow wildlife and plant populations to adjust to long-term climate change. In addition, many species of fish, such as whitefish, bull trout and walleye, are migratory. Dams and diversions that fail to provide for fish passage and the continued functioning of downstream ecosystems fragment populations and landscapes.

As shown in Table 2.16 and Figure 2.2, the total irrigated area within the ecoregion study area more than doubled between 1971 and 1991. The more significant increases occurred in the Chinook Upland and Southern Alberta Plains.

The river basin study area indicates an increase of 91 percent in irrigated area with significant increases in the Willow Creek and Belly/Waterton River basins. In addition, the river basin with the highest irrigation stress, with 11 percent of its land irrigated, is the Belly/Waterton River basin. This phenomenon is depicted in Figure 2.3.

Table 2.16
Irrigated Area by Ecoregion, 1970-1990

		Irrigated area				Proportion irrigated		Change in area		
Ecoregion	Ecoregion area	1970	1980	1985	1990	1970	1990	1970-1980	1980-1990	1970-1990
	hectares					percent				
Northern Continental Divide[1]	543 336	557	421	818	721	0.1	0.1	-24.5	71.4	29.5
Chinook Upland	714 851	6 690	8 708	13 973	16 918	0.9	2.4	30.2	94.3	152.9
Southern Alberta Plains	819 158	44 224	82 265	97 381	99 090	5.4	12.1	86.0	20.5	124.1
Study area total	**2 077 345**	**51 471**	**91 394**	**112 173**	**116 728**	**2.5**	**5.6**	**77.6**	**27.7**	**126.8**

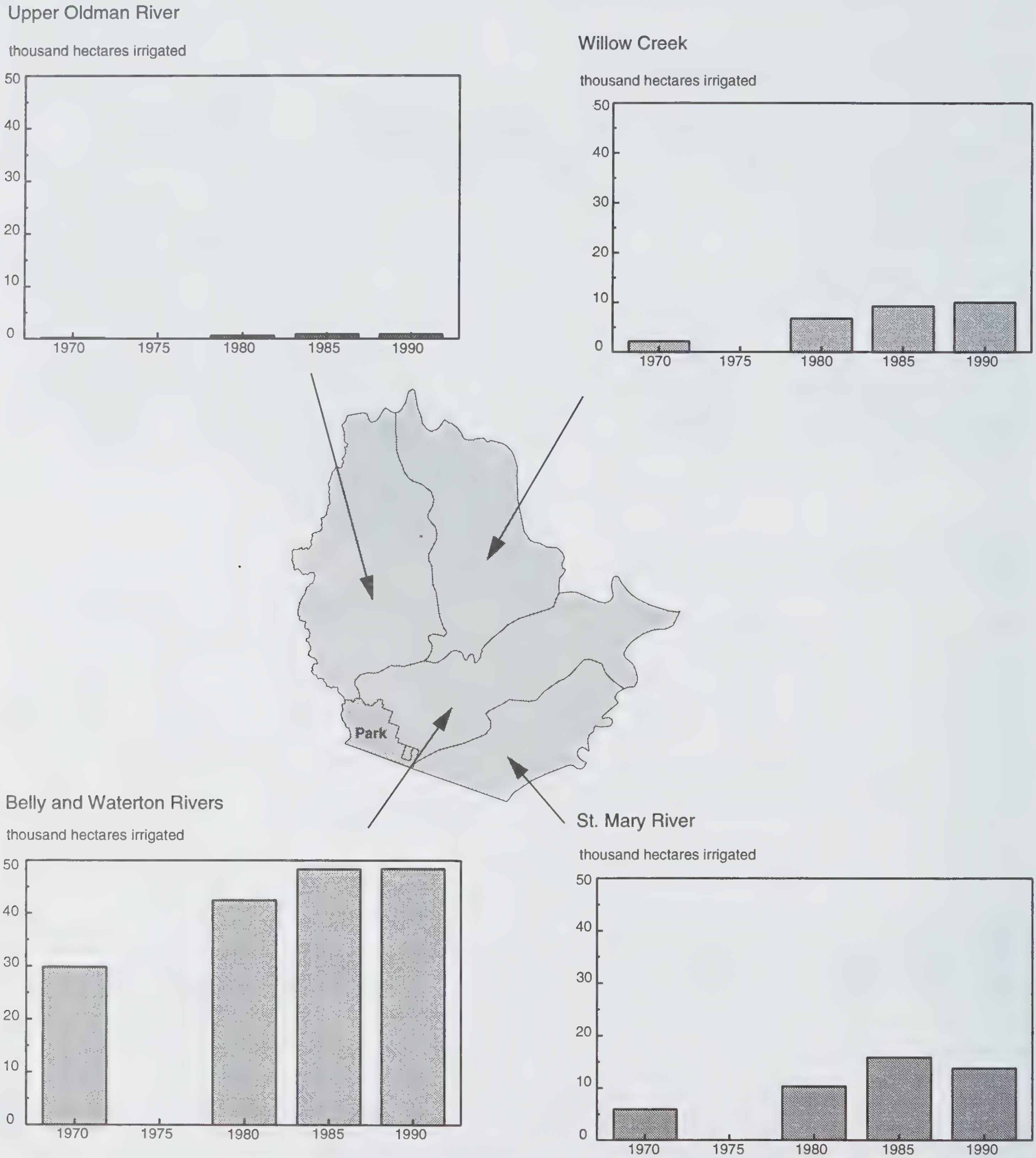
Note:
1. For the purposes of this table data for the Alberta and British Columbia portions of the Northern Continental Divide have been combined to preserve confidentiality.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.17
Irrigated Area by River Basin, 1970-1990

		Irrigated area				Proportion irrigated		Change in area		
River basin	River basin area	1970	1980	1985	1990	1970	1990	1970-1980	1980-1990	1970-1990
	hectares					percent				
Willow Creek	416 210	2 164	6 719	9 266	10 009	0.5	2.4	210.5	49.0	362.5
Upper Oldman River	494 237	218	594	843	872	-	0.2	172.3	46.9	300.0
Belly/Waterton Rivers	446 086	29 849	42 472	48 368	48 446	6.7	10.9	42.3	14.1	62.3
St. Mary River	233 311	5 950	10 291	15 835	13 746	2.6	5.9	73.0	33.6	131.0
Total[1]	**1 589 844**	**38 181**	**60 076**	**74 312**	**73 073**	**2.4**	**4.6**	**57.3**	**21.6**	**91.4**

Note:
1. This total is the sum of the four river basins and does not equal the total presented in the ecoregion summaries.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 2.3
Irrigated Area by River Basin, 1970 - 1990



Sources:
Statistics Canada, National Accounts and Environment Division and Census of Agriculture.

The use of pesticides to increase the availability of trace nutrients can improve crop yields where natural soil fertility has been depleted. Fertilizer use, however, is not only a symptom of declining soil health, it also has the potential to produce pollution problems.[1]

The total amount of fertilizer used in this area has more than doubled between 1970 and 1990, although this increase has been accompanied by more than a three-fold increase in the area being fertilized. These factors together have led to reductions in the rate of fertilizer application in the 1970-1990 period, as shown in Tables 2.18 and 2.19.

In the river basin study area, the lowest decrease in fertilizer application occurred in the Upper Oldman River basin. This area also experienced the highest increase in farmland and maintained the most consistent application rate of fertilizer between 1970 and 1990 at 139 kg per hectare.

Overall, the intensity of fertilizer application in the area surrounding Waterton Lakes National Park is lower than the national average of 180 kg per hectare.

1. Government of Canada, 1991, p. 9-21.

Table 2.18

Commercial Agricultural Fertilizer Application by Ecoregion, 1970-1990

	Commercial fertilizer tonnage				Area fertilized				Application rate			
Provincial ecoregion	1970	1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990
	tonnes			percent	hectares			percent	kg/hectare			percent
Northern Continental Divide[1]	528	1 231	1 280	142.4	3 844	8 882	9 471	146.4	137.4	138.6	135.2	-1.6
Chinook Upland	8 669	25 081	29 389	239.0	57 511	187 186	249 611	334.0	150.7	134.0	117.7	-21.9
Southern Alberta Plains	14 738	41 503	37 102	151.7	79 693	304 887	295 501	270.8	184.9	136.1	125.5	-32.1
Study area total	**23 935**	**67 815**	**67 771**	**183.1**	**141 048**	**500 956**	**554 583**	**293.2**	**169.7**	**135.4**	**122.2**	**-28.0**

Note:
1. For purposes of this table data for the Alberta and British Columbia portions of the Northern Continental Divide have been combined to preserve confidentiality.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 2.19

Commercial Agricultural Fertilizer Application by River Basin, 1970-1990

	Commercial fertilizer tonnage				Area fertilized				Application rate			
River basin	1970	1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990	1970	1980	1990	Change 1970-1990
	tonnes			percent	hectares			percent	kg/hectare			percent
Willow Creek	2 956	9 516	7 622	157.8	21 431	78 789	66 264	209.2	137.9	120.8	115.0	-16.6
Upper Oldman River	1 478	4 329	2 521	70.6	10 432	31 438	18 150	74.0	141.7	137.7	138.9	-2.0
Belly/Waterton Rivers	7 932	18 768	13 751	73.4	40 192	116 837	102 859	155.9	197.4	160.6	133.7	-32.3
St. Mary River	4 770	15 417	16 838	253.0	30 725	111 266	134 930	339.2	155.2	138.6	124.8	-19.6
Total[1]	**17 136**	**48 030**	**40 733**	**137.7**	**102 780**	**338 329**	**322 203**	**213.5**	**166.7**	**142.0**	**126.4**	**-24.2**

Note:
1. This total is the sum of the four river basins and does not equal the total represented in the ecoregion summaries.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Conclusion

The Canadian portion of the Crown of the Continent ecosystem contains extensive areas where natural processes continue to operate and where the area's original biological diversity survives. This is due, in part, to the presence of a protected core area, Waterton Lakes National Park. It is also due to the quality of stewardship accorded to the agricultural and public lands that make up most of the remaining area.

Within the Crown, Waterton Lakes National Park has been set aside for the people of Canada, to be kept unimpaired for all time. As a Man and Biosphere reserve, the park's ecological health serves as a benchmark for the larger area. By and large, the signs are good. Wolves, sandhill cranes and trumpeter swans, once exterminated, now breed in small numbers in the area. Grizzly bears still range the landscape, and populations of elk, deer, bighorn sheep and moose remain healthy.

However, some environmental stresses are becoming more evident in the Crown. Bull trout populations have declined dramatically due to dams, overfishing and habitat deterioration (Fitch, 1994). Cottonwood forests have declined by as much as 55 percent along the Waterton and St. Mary Rivers (Rood, 1987). Speculative interest in converting agricultural land to residential or recreational land has also been increasing (Pickell, 1994).

Data evaluated for this study indicate that the largest relative changes over the study period took place in the Northern Continental Divide ecoregion. Changes in this ecoregion have a particularly large impact because of the relatively pristine state of the region.

Within the Alberta portion of the study area, the Upper Oldman and St. Mary River basins experienced marked increases in farmland acreage (Table 2.5). As well, there were large increases in the use of agricultural pesticides throughout the study area, with increases greater than fourfold occurring in the Chinook Upland ecoregion and in the St. Mary River basin. Irrigated acreage quadrupled in the Willow Creek and Upper Oldman River basins (Table 2.17).

All of the above facts lead to important questions that will have to be answered if the relationship between the park and its surroundings is to remain stable in the long term. The balance between the Crown of the Continent's ecosystem integrity, and a viable socio-economy will have to be carefully monitored as we move into the 21st century.

References

Demarchi, D.A. and E.C. Lea, 1993, ***Regional and Zonal Ecosystems in the Shining Mountains,*** British Columbia Ministry of the Environment, Lands and Parks, Wildlife Branch, Habitat Inventory Section, Victoria, British Columbia.

Dumanski *et al.*, 1986, "Soil Conservation in Canada", ***Journal of Soil and Water Conservation***, Soil Conservation Society of America.

Fitch, L., 1994, ***Status of Bull Trout in the Oldman River Basin,*** Proceedings of the Friends of the Bull Trout Conference, Calgary, Alberta.

Government of Canada, 1991, ***The State of Canada's Environment***, Ottawa.

Hamilton K.E. and Trant D.F., 1989, "Statistical Aspects of the Application of Geographic Information Systems in Canadian Environment Statistics", ***Journal of Official Statistics,*** Statistics Sweden, 5 (4), p. 337-348.

Pickell, Doug, 1994, Planning Development Officer, M.D. of Pincher Creek, Personal Communication.

Rood, S.B. and F. Heinze-Milne, 1987, Abrupt Downstream Forest Decline Following River Damming in Southern Alberta, ***Canadian Journal of Botany,*** 67 (6), p. 1744-1749.

Statistics Canada, 1992, ***Agricultural Profile of Alberta, Part 1,*** Agriculture Division, Ottawa.

______, 1994, ***Human Activity and the Environment 1994***, Cat. No. 11-509E, Ottawa.

World Wildlife Fund Canada,1989, ***Prairie Conservation Action Plan,*** ISBN 0-9693730-0-7, Toronto, Ontario.

3 Household Waste Management in the '90s: Reduce, Reuse and Recycle

by Murray Cameron[1]

Introduction

Environment Canada estimates that over 32 million tonnes of solid wastes are generated each year in Canada[2]. Residential waste accounts for almost half of this amount[3].

Waste[4] presents one of the greatest challenges to the Canadian environment. Excessive solid wastes are creating problems for communities which have no more land available for landfill sites. Effective use of the 3Rs - reduction, reuse and recycling - helps to protect the environment by reducing pressure on communities for disposal lands through significant cuts in the waste stream.

This chapter highlights some of the results from the 1993 Local Government Waste Management Survey[5]. This national survey sampled 642 municipalities Canada-wide and included questions on garbage collection, recycling, composting and the handling of hazardous waste. The municipalities surveyed accounted for approximately 79 percent of the Canadian population in 1993.

The survey was the second of its kind conducted by Statistics Canada. As a follow-up to the original pilot study conducted in 1991 (see Text Box 3.1), it was intended to provide an overview of the structure and function of Canadian local government waste management activities. A number of definitional problems were identified in the pilot survey and were subsequently corrected for the 1993 survey. As a consequence, comparisons between years cannot readily be made.

1. The author would like to thank Marcia Santiago for her valuable assistance.
2. Environment Canada, Office of Waste Management.
3. Statistics Canada, 1993.
4. Waste is defined as any substance discarded for final disposal or recycling for which the owner or generator has no further use.
5. A complete survey report is available from National Accounts and Environment Division, Statistics Canada.

Text Box 3.1

Highlights of the 1991 Pilot Local Government Waste Management Practices Survey[1]

The survey, conducted in 1990/1991, contained a number of questions designed to profile the practices of local governments including the collection, transportation and disposal of garbage, as well as recycling and the handling of hazardous waste. As a pilot study, it was intended to obtain an overview of the structure and function of Canadian local government activities pertaining to waste management.

Some highlights[2] include:

Based upon the total annual quantities reported, 83 large municipalities collected, on average, about 1 tonne of residential garbage per dwelling per year or 2.5 kilograms per day. Seventy-three of these municipalities had a recycling program, through which approximately 9 percent (by weight) of the total municipal garbage was recycled.

Fifty-six of the municipalities had some form of residential hazardous waste program while only 10 had a program for non-residential hazardous wastes.

Thirty-six of the municipalities reported having arranged for waste composition studies, an important step towards effective waste management. In addition, 53 of the municipalities had some form of waste reduction program.

1. Statistics Canada, 1993.
2. The data presented in the article reflected 83 municipalities that had a population greater than 50 000 in 1991. These accounted for about half of the Canadian population.

Waste not ...

Whether we are aware of it or not, we pollute our environment daily in many ways. The very act of preparing food generates many by-products, such as residues from organic matter and packaging, that have to be disposed of. It is how we dispose of these wastes that has an impact on our environment.

Much of the material entering landfills can be recycled or composted. Although education programs help to inform households about recycling, composting and hazardous waste disposal, organized recycling and composting programs offer the best hope for protecting the environment against further degradation.

Waste collection[1]

Among the 642 municipalities surveyed, an average of 2.5 kilograms per day of residential waste was collected from each dwelling served (see Figure 3.1). Those municipalities with under 30 000 in population reported higher levels of garbage collected, averaging 2.8 kg/day/dwelling.

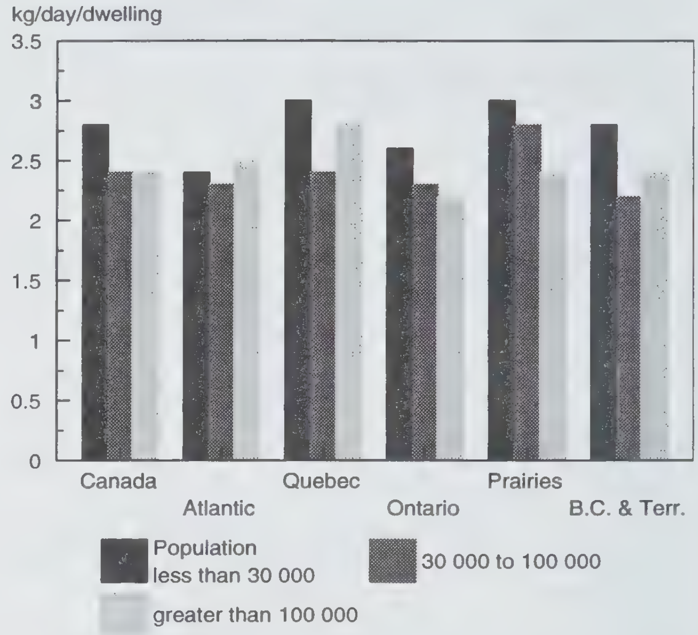
Overall, waste collection is primarily handled by contractors hired by municipalities. Overall 62 percent of municipalities reported using contractors only while 13 percent used their own employees for this task (Table 3.1). No waste collection programs were reported in 8 percent of the municipalities - many were communities of under 30 000.

In Quebec, only 2 percent of the municipalities used only municipal employees for waste collection, while 84 percent of Quebec municipalities employed contractors only.

The Prairie region had the highest incidence of municipalities with no waste collection programs, 18 percent or 19 municipalities, while Quebec had the lowest incidence of municipalities with no waste collection, at 4 percent.

1. This section refers to waste collection for disposal, which is waste destined for landfill, incineration or export.

Figure 3.1
Residential Waste Collected for Disposal, per Dwelling, by Municipality Size, 1993



Note:
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

Table 3.1
Waste Collection by Agent Responsible, Municipality Size and Region, 1993

	Municipal population				Region				
	Under 30 000	30 000 - 99 999	100 000 and over	**Canada**	Atlantic provinces	Quebec	Ontario	Prairie provinces	B.C., Yukon and N.W.T.
Number of municipalities reporting	508	97	37	**642**	64	189	218	104	67
Agent responsible for collection	percent of municipalities reporting								
Municipal employees only	12	15	19	**13**	19	2	13	19	30
Contractors only	64	60	38	**62**	48	84	67	40	33
Other	5	1	-	**4**	6	5	2	2	12
Municipal employees and other	2	8	5	**3**	3	-	2	8	12
Contractors and other	3	1	5	**3**	-	3	3	2	3
Municipal employees and contractors	4	7	32	**6**	11	2	6	10	4
Municipal employees, contractors and other	-	4	3	**1**	2	-	1	1	1
No program	9	3	-	**8**	11	4	6	18	4
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Notes:
Figures may not add due to rounding.
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

Recycling

Across Canada, the majority of municipalities surveyed reported having a household recycling program in place in 1993 (Table 3.2), through which approximately 16 percent (by weight) of the total residential waste stream was recycled.

Regionally the incidence of recycling programs in municipalities surveyed varied from a high of 91 percent in Ontario to a low of 31 percent in the Atlantic Provinces.

Collection of recyclable materials was handled primarily by contractors to the municipalities as reported by 36 percent of the sample, as shown in Table 3.3. Other organizations accounted for the next largest collection mechanism, 23 percent of the municipalities. Municipal employees were used in fewer municipalities for recyclables collection (7 percent) as compared to general waste collection (13 percent) shown in Table 3.1.

All reporting municipalities relied primarily on contractors or private haulage (Table 3.3).

Of the recyclable materials collected in 1993 (see Table 3.4), newspaper, at 16.3 kg/person, ranked as the largest

Table 3.2
Recycling and Program Availability by Municipality Size and Region, 1993

	Municipal population				Region				
	Under 30 000	30 000 - 99 999	100 000 and over	**Canada**	Atlantic provinces	Quebec	Ontario	Prairie provinces	B.C., Yukon and N.W.T.
Number of municipalities reporting	508	97	37	**642**	64	189	218	104	67
	percent								
Municipalities with recycling program	68	93	100	**73**	31	70	91	60	87
Waste recycled as a proportion of total waste collected	23	16	13	**16**	40	9	20	13	17

Note:
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

Table 3.3
Collection of Recyclable Materials by Agent Responsible, Municipality Size and Region, 1993

	Municipal population				Region				
	Under 30 000	30 000 - 99 999	100 000 and over	**Canada**	Atlantic provinces	Quebec	Ontario	Prairie provinces	B.C., Yukon and N.W.T.
Number of municipalities reporting	508	97	37	**642**	64	189	218	104	67
Agent responsible for collection	percent of municipalities reporting								
Municipal employees only	6	5	27	**7**	2	3	7	13	13
Contractors only	31	55	46	**36**	11	52	44	8	27
Other	25	18	11	**23**	14	12	30	25	40
Municipal employees and other	1	2	3	**2**	3	-	1	5	-
Contractors and other	1	5	3	**2**	-	2	2	2	3
Municipal employees and contractors	2	6	5	**3**	2	1	4	6	3
Municipal employees, contractors and other	--	2	5	**1**	2	-	2	1	-
No program	32	7	-	**27**	67	30	9	40	13
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Notes:
Figures may not add due to rounding.
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

contributor to the recyclables stream (Figure 3.2). Paper products as a whole accounted for 23 kg/person, or 65 percent of all recyclables.

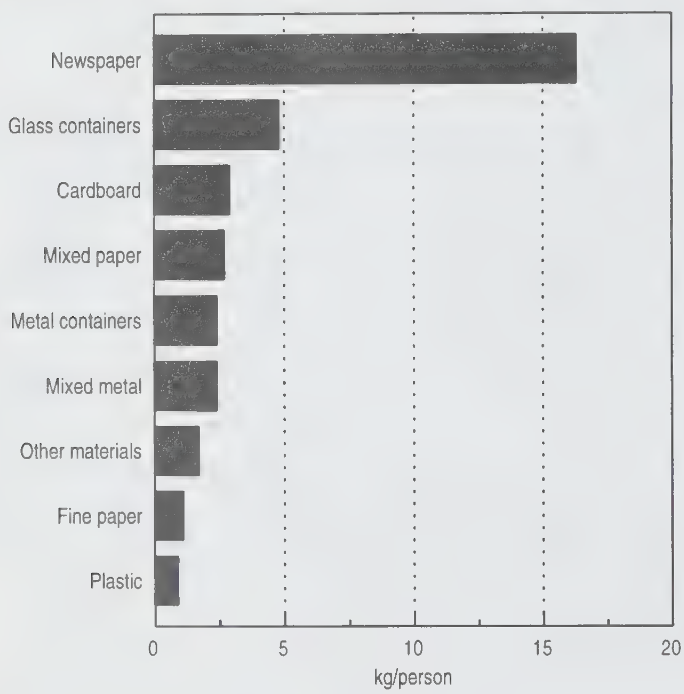
With respect to population served by recycling programs, the proportion of the total Canadian population served increased from 1990 to 1993 (see Table 3.5). Regionally most areas of the country reported an increase with Quebec making the largest gain.

Table 3.4
Material Collected for Recycling, 1993

Materials	Composition	Quantity
	percent	kilograms per person
Newspaper	46	16.3
Glass containers	14	4.8
Cardboard	8	2.9
Mixed paper	8	2.7
Metal containers	7	2.4
Mixed metal	7	2.4
Other materials	6	1.7
Fine paper	3	1.1
Plastic	3	0.9
Total	**100**	**35.1**
Municipalities reporting	451	451

Note:
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled, or municipalities that did not report the quantity of materials collected for recycling.
Source:
Statistics Canada, National Accounts and Environment Division.

Figure 3.2
Material Collected for Recycling, 1993



Note:
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

Table 3.5
Proportion of Population with Access to Recycling Programs, 1990 and 1993

	1990	1993
Atlantic provinces	0.52	0.46
Quebec	0.61	0.85
Ontario	0.96	0.98
Prairie provinces	0.77	0.89
B.C., Yukon and N.W.T.	0.86	0.96
Canada	**0.80**	**0.91**

Note:
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

Hazardous waste programs

Across Canada, hazardous waste programs were reported in 290 municipalities, or 45 percent of the 642 municipalities surveyed (Table 3.6). Of the 290 municipalities with hazardous waste programs, 210 (72 percent) had less than 30 000 in population.

Fifty-four communities between 30 000 and 100 000 in population reported a hazardous waste program, while 26 municipalities over 100 000 in population reported similar programs. The Prairies reported the highest regional rate with 61 percent of municipalities surveyed reporting some type of program (63 municipalities).

Of those communities reporting a hazardous waste program, 96 percent employ the depot system for collection while the remaining 3 percent used either a curbside pick-up program or did not specify.

Composting and other programs

Composting of organic wastes is one way municipalities can reduce the amount of waste destined for landfills.

Table 3.7 shows that of the 642 municipalities surveyed, 216 (34 percent) reported a compostables collection program. These municipalities offer residents yard waste pick-up during the spring and fall as well as Christmas tree collection in January. Ontario led the way in these types of programs with 51 percent of its municipalities (111) having participated[1].

Municipalities also actively encourage composting programs through sponsoring and distributing backyard composters. Across Canada 50 percent of municipalities surveyed reported such programs. Ontario reported the highest incidence with 87 percent of its municipalities distributing backyard composters (Table 3.7).

Many communities put a high priority on reducing the amount of garbage generated. As shown in Table 3.7, 27 percent of municipalities across Canada have undertak-

1. These figures do not include estimates for municipalities with a population less than 5 000, which were not sampled.

Table 3.6
Hazardous Waste Programs by Municipality Size and Region, 1993

	Municipal population				Region				
	Under 30 000	30 000 - 99 999	100 000 and over	**Canada**	Atlantic provinces	Quebec	Ontario	Prairie provinces	B.C., Yukon and N.W.T.
Number of municipalities reporting	210	54	26	**290**	8	84	127	63	8
	percent of municipalities reporting								
Curbside	2	-	15	**3**	12	2	4	1	-
Depot	95	100	96	**96**	75	93	99	97	100

Notes:
Figures do not add to 100 percent as municipalities may offer more than one type of program.
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

Table 3.7
Other Municipal Waste Management Service Programs by Municipality Size and Region, 1993

	Municipal population				Region				
	Under 30 000	30 000 - 99 999	100 000 and over	**Canada**	Atlantic provinces	Quebec	Ontario	Prairie provinces	B.C., Yukon and N.W.T.
Number of municipalities reporting	508	97	37	**642**	64	189	218	104	67
	percent of municipalities reporting								
Compostables collection	27	51	76	**34**	20	25	51	25	28
Distribution of backyard composters	46	62	76	**50**	22	32	87	19	60
Waste composition studies	24	35	46	**27**	45	22	24	29	33
Public education programs	50	76	89	**56**	52	42	70	54	58

Note:
These are preliminary figures and do not include estimates for municipalities with a population less than 5 000, which were not sampled.
Source:
Statistics Canada, National Accounts and Environment Division.

en waste composition studies to determine how to reduce waste. More than half of the municipalities surveyed (56 percent) also provide public education programs designed to promote waste reduction at the residential level. Both of these initiatives are important steps towards effective waste management.

Conclusion

One of the most effective ways to limit the amount of waste being discarded is through the implementation of the 3Rs - reduce, reuse and recycle. Canadians appreciate that there are limits to how much garbage the environment can absorb, as well as how much of the environment they are willing to sacrifice for waste disposal purposes.

Nationally, the proportion of the Canadian population served by recycling programs increased from 1990 to 1993. This result underlines the importance of this kind of survey, since it provides a gauge to the progress being made with respect to residential waste management practices across Canada. Plans are underway to conduct this survey on a regular basis.

References

Statistics Canada, 1993, "Local Government Waste Management Practices Survey", ***Environmental Perspectives 1993: Studies and Statistics***, Cat. No. 11-528E, Ottawa.

4 Measuring Ontario's Timber Resource

by Rick Moll and Greg Lawrance

Introduction

The physical timber resource stock account described in this chapter is one of a number of resource stock accounts being developed by Statistics Canada. These accounts will form an environmental component of the Canadian System of National Accounts, the major statistical framework for the measurement of economic activity in Canada. The purpose of this component is the measurement of the effect and dependence of economic activity on the environment. Four groups of accounts are being developed to cover natural resource stocks, natural resource use, waste or pollutant output and environmental expenditure.

The development of timber resource stock accounts started with an Ontario pilot project, carried out with the assistance of the Ontario Ministry of Natural Resources (OMNR). The first phase of this project, construction of historical time series estimates for forest stock data, is complete.

Physical account

The physical accounts estimate a series of yearly stock data which show the area covered by accessible and potentially commercial forest land and describe the volume, age and species composition. The change in these stocks from year to year and the reasons for this change, such as growth, harvest, natural loss or change in land use, are also presented. The physical accounts are based on forest inventories produced by the province. These inventories are carried out periodically for different land bases so that stock data are not available as a time series. To obtain a time series for the accounts, missing years' data are estimated by using a model which starts with inventory data for a year and simulates the impact of growth, harvesting, natural loss and other changes.

The physical accounts show the evolution of forest land over an historical time period: 1953 to 1991. This type of simulation is similar to a wood supply analysis done by the provincial managers of the forest. The data in the physical accounts are not limited to a description of timber or the production forest, but could cover all forest land. Other information that could be included are details of ownership, use, or accessibility.

Timber resource accounting structure

The Ontario timber resource account involves the development of a simulation framework, **STCMacroForest**, which is conceptually similar to a population model (Moll, 1992); it evolves an age-distributed stock (area) of forest land over time and is classed as a positive linear systems model (Luenberger, 1979).

STCMacroForest for Ontario distinguishes twenty four districts that contain productive stocked and nonstocked nonreserved forest land. Stocked forest land (Haddon, 1988) is land supporting tree growth which in this context includes seedlings and saplings. Nonstocked forest land (Haddon, 1988) is productive forest land that lacks trees completely or that is so deficient in trees the residual stand of merchantable tree species will be insufficient to allow utilization in an economic operation. Within each district, the framework distinguishes three cover types (coniferous, mixedwood and hardwood) and 180 single year age classes.

STCMacroForest attempts to integrate the processes of fire, mortality, harvesting, aging, natural and artificial (planting) regeneration with the forest inventory data over a historical period 1953 to 1991. This period was originally chosen because the Ontario 1953 Forest Resources Inventory (Ontario FRI, 1953) provided the only initial condition for the simulation. However, this inventory did not provide a numerically defined age class distribution. A first attempt to calibrate the model used an assumed age class distribution derived from the aggregate maturity classes given in the 1953 FRI. However, using these initial conditions the 1991 target age class distribution was not met, therefore, a different approach was adopted. First, a 1953 inventory is estimated by running the simulation model backwards. Using the estimated 1953 age class distribution, as the initial condition, the model was ran forwards to meet the desired 1991 data points. This method will be described in more detail in the section entitled **model validation**.

The 1991 Ontario FRI was used as the end point of the simulation. The 24 districts used in the 1953 FRI were the basis of the geographic detail of the simulation model. These boundaries were maintained because most of the change data conforms with this spatial resolution.

The following are the main factors which give rise to changes in the simulated forest stock over time:

- growth and endemic mortality due to disease and insects are absorbed in the volume per hectare as a function of age (empirical yield curves);
- catastrophic stand mortality due to fire (fire rates);

- annual volume harvested given by cubic metres of softwood and hardwood roundwood;
- aging and natural regeneration after fire; and
- artificial and other natural regeneration.

These factors will be described in more detail in the following sections. First, the input and output variables are defined together with the structure of the calculation sequence during a year of the above mentioned processes.

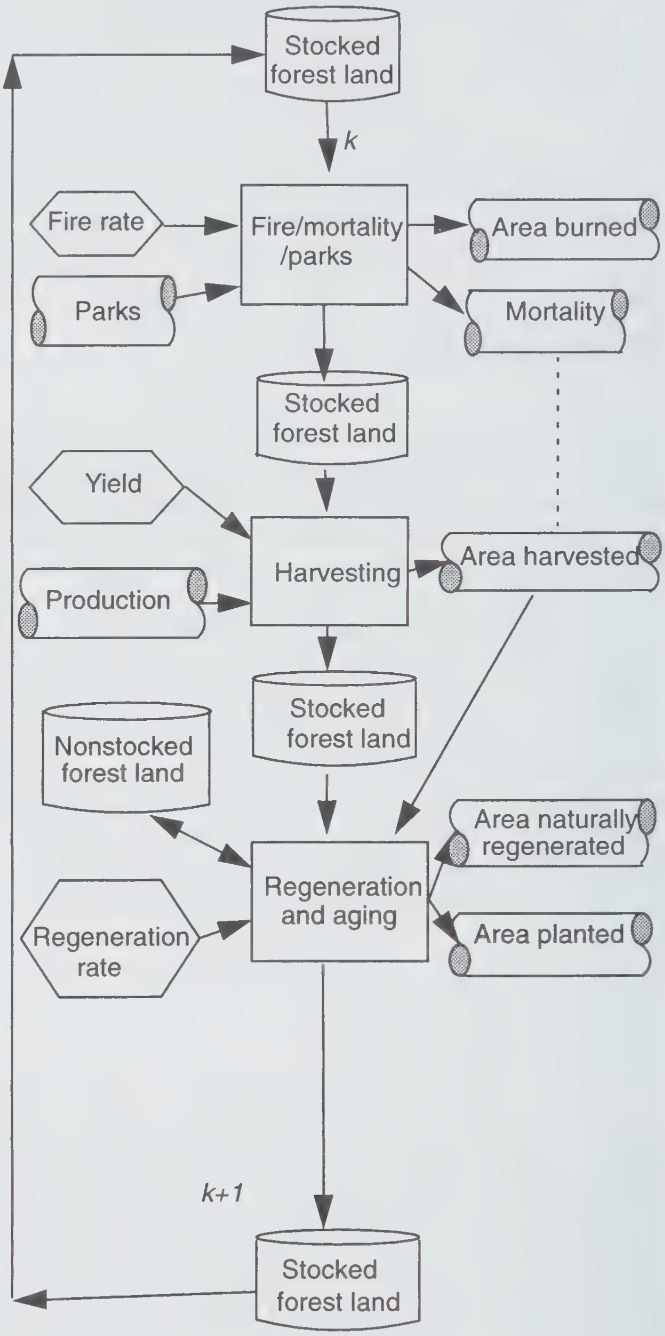
Time loop structure

Figure 4.1 outlines an overview of the calculation sequence of **STCMacroForest**. The inputs and outputs associated with the processes of fire, mortality, adjustment for parks, harvesting, aging and regeneration are shown. These show the order in which the calculations are performed during one year of the accounting period. As can be seen from Figure 4.1 the stocked forest land at the start of a period is adjusted for loss due to fires and natural mortality. Forest land area which became parkland is also removed from the exploitable forest land base. The surviving stocked forest land is input to the harvesting calculation where the annual roundwood production (m^3 of timber) is translated into area harvested from the stocked forest land.

It is assumed that area burned regenerates as the same cover type. This is modeled by burned area regenerating in the first age class at the start of the subsequent year. Mortality is simulated by the disappearance of the area in the oldest age class each year. This area is spread equally over all other age classes to approximate the natural growth of an understorey. The harvesting algorithm assumes that the harvest area cut is met by proration of the cut according to the distribution of the potential volume of timber in the allowable age classes. Harvesting of two wood types: "softwood" and "hardwood" may be performed in three cover types.

In the last block newly harvested area regenerates either by planting or natural regeneration. Regeneration of nonstocked forest land also occurs at this stage. Finally, the stocked forest land is aged by shifting area from each age class to the next oldest age class. The year index is incremented and the calculations are repeated for as many years as there are in the simulation time horizon. In the next sections the processes of fire, mortality, harvesting, aging and regeneration will described in more detail.

Figure 4.1
Time Loop Structure



Indices and Sets

The algebraic idiom of multi-dimensional arrays is used to represent the data objects which comprise the inputs and outputs of the accounting framework. First the stratification of each dimension is defined by describing the elements of each set as shown in Text Box 4.1. Sets are fundamental building blocks and allow a model to be succinctly stated. The sets describe the level of disaggregation while providing a notation for indexing. The elements in a set (titleset) are the labels.

Forest fires, mortality and parks

In Figure 4.1, three adjustments to the forest land stock during a period of the simulation year are represented. In the first block these are reductions of stocked productive forest due to fire, natural mortality and newly created parks.

Text Box 4.1
Titleset Definitions

Index	Titleset elements	Titleset name	Dimension
k	1953-1991	years	39
i	1 to 180	age class180	180
s	coniferous mixedwood hardwood	cover types	3
d	North Bay Timiskaming Cochrane Kapuskasing Geraldton Thunder Bay Pembroke Parry Sound White River Sudbury Sault Ste. Marie Chapleau Gogama Fort Frances Kenora Sioux Lookout Kemptville Tweed Lindsay Lake Simcoe Lake Huron Lake Erie PEA East PEA West	districts	24
w	softwood hardwood	wood type	2

Forest land is updated for fire by decreasing the inventory according to historical fires. Fire rates are available for the years 1953 to 1991 and were obtained for each of the 24 districts. At the 'provincial level' the fire losses for 1953 to 1991 demonstrate considerable variability. The significance of 500 000 hectares of forest burned in one district (Sioux-Lookout) in one year by an unknown number of fires is not demonstrated. Fires of this size will have a considerable impact on the future age class distribution of the forest. Fire data are not available on a cover type- or age- specific basis. The fire rates were calculated for each year and district as a percentage of the area burned to the total forest land area for that district. These rates were then applied uniformly for each age class and cover type of the forest land stock. The area burned stratified by age, cover type and district is subtracted from the stock. The area burned is summarized by cover type and district and regenerated in the youngest age class at the start of the subsequent year.

The surviving stocked forest land is input to a mortality process where the area of forest which reaches the oldest age class (180 years) is assumed to die naturally. Then the forest land inventory is adjusted for transfers to park land. A historical time series of park land additions is known by district and this series is pro-rated according to the age class and cover type distribution of forest land for each year.

Harvesting

In Figure 4.1 the second process represents how the historical production of roundwood (softwood and hardwood) are translated into area harvested so that the forest land stock can be adjusted each year. The forest is cut according to historical data for roundwood production volume (cubic metres). Two types of roundwood volume were provided as input to the harvesting algorithm: softwood and hardwood. In this accounting framework, 75 percent of the softwood volume was harvested from "coniferous" and 25 percent from "mixedwood" stands. All the hardwood volume was met by harvesting from the "hardwood" cover type. First, the potential volume for softwood timber in the two cover types "coniferous" and "mixedwood" is calculated by multiplying the unit volume per hectare yield for softwood timber by the forest land area and summing over the selected allowable age classes. These are the ages from which harvesting may occur and are called the limits of operability. This is the period in the stand's development when there is sufficient volume so that they may be economically harvested. For softwood, the age class range from which harvesting can occur was 60-180 years.

Similarly, the potential hardwood volume was calculated by multiplying the forest land area in hardwood cover type by the unit volume per hectare for hardwood wood type in hardwood cover type and summing over the age classes 50 to 180. Harvesting of younger hardwood stands was allowed. Then the ratio of roundwood produced to the potential volume that could be harvested was calculated. This proportion (harvest ratio) was used to determine how much area of forest needed to be cut to satisfy the production in each year. In other words the harvest was allocated across age classes by the proportion of the wood produced to the total potential volume in each cover type.

An allowance of three percent of annual area harvested was made for the construction of roads in the forest. Stocked productive forest land is therefore reduced by three percent of the area harvested each year since newly created roads are not regenerated as stocked forest land.

After harvesting recently cut land is aggregated each year by district and cover type by summing the area cut over wood type and the age classes in which harvesting was permitted. This forest land is then passed to the final block which represents the regeneration process.

Aging and natural regeneration of burn and mortality

Aging of the forest, natural regeneration due to fire and natural mortality are represented in the last block of Figure 4.1. It is assumed that regeneration occurs immediately after both fire and natural mortality.

Natural regeneration of depletions due to fire are achieved by updating the first age class of stocked forest land at the start of the next simulation year. First the area burned is summarized by cover type and district in each year. Then the stocked forest land in age class 1 for year *k+1* is updated by the area burned during year *k*. It is assumed that the area regenerates to the same cover type after a burn.

Forest that died during year *k* is regenerated in the following way. Rather than regenerating this area in age class one at the start of the next year this area is distributed amongst the age classes 1 to 179 according to the current age class and cover type distribution. The reasoning behind this is that in a stand mortality is not an abrupt process. Trees do not die off as soon as they reach 180 years. There is mortality in the stand and regeneration in the form of an understorey is always present. In order to capture this natural evolution of the forest stand the 180 year old age class is allocated amongst the other age classes.

The remaining age classes of the stocked forest land are aged by one year. This simple process is due to the single year representation of the age class structure of the forest.

Artificial and natural regeneration of cut

Natural and artificial regeneration of recently harvested and previously nonstocked forest land is represented by the last block. Area which naturally regenerates is distinguished from artificial regeneration through planting by multiplying by the natural regeneration share. A 50 percent natural regeneration rate is assumed. The regeneration rates for both newly cut forest land and previously nonstocked forest land determine how fast these area types regenerate. The regeneration rate for newly cut land was 0.7 and that for nonstocked .01. In other words the nonstocked land slowly regenerates to stocked whereas the new cut land regenerates quickly.

Succession in regeneration is represented by distinguishing the probability of transition to different cover types after harvest and planting. Data on regeneration after harvest and planting were available (Hearnden, Wilson and Millson, 1992) and absorbed in two regeneration transition matrices; one for natural regeneration and one for planting. The regeneration transition matrices are dimensioned 3 cover types by 3 cover types indicating by row the propensity of regenerating from one cover type to another.

The nonstocked forest land for beginning of year *k+1* is updated by including the proportion of newly cut forest which will be nonstocked plus the surviving nonstocked forest land from the end of the previous year *k*.

Finally, stocked forest land is updated at the beginning of year *k+1* in age class 1 for natural and artificial regeneration of harvested and nonstocked forest land during year *k*.

Data preparation

The final results of the project depend on the quality of data used by the model. This section focuses on describing the origin and characteristics of the different data used by the project, and some of the processing necessary to prepare the data for model input. Considerable effort was necessary to recode and format data for input into the model structure. The principal difficulty encountered was obtaining input data for each of the model's input variables referenced to common geographic areas for the 40 years.

Geographical units

Selection of the appropriate levels of spatial, temporal and categorical resolution for model elements and data is difficult. Compromises in the form of aggregation are necessary because not all data are available for the same geographic areas, in the same format, over the entire time period.

Although provincial estimates are the objective of the project, the spatial dependencies of much of the data (e.g. yield, fire, harvest) suggested that modeling at the sub-provincial level and aggregating up to a provincial total would produce more accurate results than modeling at the provincial total level.

OMNR divides the province into a number of geographically defined management units for the purpose of preparing resource plans. These management units form the statistical frame for the collection and reporting of the majority of data pertaining to the resource.

Similarly, in order to efficiently coordinate forest resource management, the province aggregates management units into geographically defined regions, districts, and areas. Like the management unit, these administrative units are often used to define the frame for data collection and reporting. Neither the management unit nor administrative boundaries have remained stable over the entire period of the historic account.

The geographic boundaries with the most longevity during the 40 years of the account were those of the 22 districts of the Lands & Forest (L&F). These boundaries also coincided well with early forest inventory data which could be used as a test against the simulation model results.

1991 Canada Forest Inventory

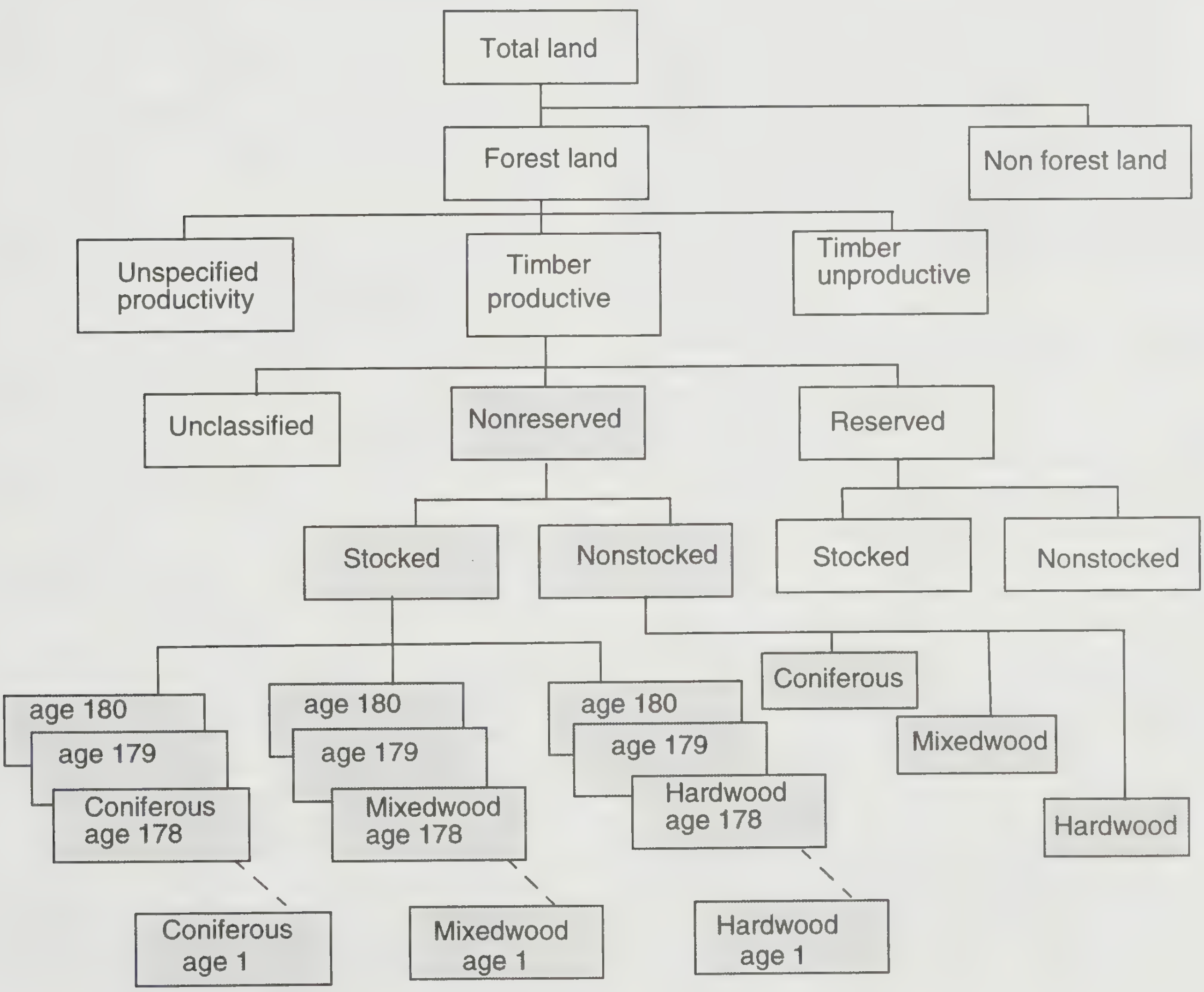
The original project plan was to use a composite 1953 inventory of the province as a starting point for the time series and evolve to the 1991 Canada Forest Inventory (CanFI) of Ontario.

The project now exclusively uses the Canada Forest Inventory (CanFI) for Ontario, maintained by the Canadian Forest Service. This inventory is a collection of over 100 inventories of different parts of Ontario, conducted by the provincial and federal governments over a time-span of 25 years.

The majority of the inventories which comprise the CanFI for Ontario were originally carried out to facilitate resource planning on geographically defined management units. These management unit inventories, known as forest resource inventories (FRI), are conducted at approximately 20-year intervals. This means that the average age of the inventories held in the CanFI is close to 10 years. Unfortunately, the names and boundaries of the management units are frequently changed so it is very difficult to track the state of the resource through time.

For the purposes of the account the CanFI recorded area, and softwood and hardwood net merchantable volume over 24 districts, 3 broad cover types (coniferous, mixedwood or hardwood) and nine 20-year age classes. The inventory area classification may be represented hierarchically as shown in Figure 4.2. Out of a total area of forest land of 57.4 million hectares 41.9 million were timber productive and 15.5 million timber unproductive. The timber productive forest land was further broken down into reserved (1.5 million hectares) and nonreserved (35.3 million hectares). The nonreserved stocked and nonstocked timber productive forest land areas were used in the simulation model. These area classifications are shaded in the hierarchy shown in Figure 4.2.

Figure 4.2
1991 Canada Forest Inventory



Digital map creation

Since district specific data were not available, a means to convert to and from this geographical level of detail was necessary. A digital map of the 22 districts was developed, supplemented by two additional northern districts (PEA[1] East & West), using various background coverages[2] and hard-copy inventory maps for guidance. CFI data is referenced to an irregular geographic grid which divides the province into approximately 4 500 cells. These data were aggregated to the 24 districts through a process of overlaying the boundaries of the districts on the centroids of the CFI cells. A cross-reference table linking the cells to the districts was then created and used to aggregate the cell level data up to a district level using a relational database.

Forest fire data

The simulation framework required estimates of area by cover type and age consumed by fire in each district/region during a year. The following notes detail the availability of data over the modeling period:

1953-55: Volume of standing timber burned (cu.ft), and its value, was recorded in the annual statistical reports, by each of the 22 districts. Using these volume loss estimates the provincial area burned was apportioned among districts. Provincial estimates (1951-1961) of the distribution of the area burned by cover types and land classes (e.g. non-forest, cutover, plantation) were used to reduce the area burned statistics by 6 percent (to account for non-forest area burned) and to estimate the portion of the area burned occurring in stocked forest (79%) versus nonstocked forest (21%).

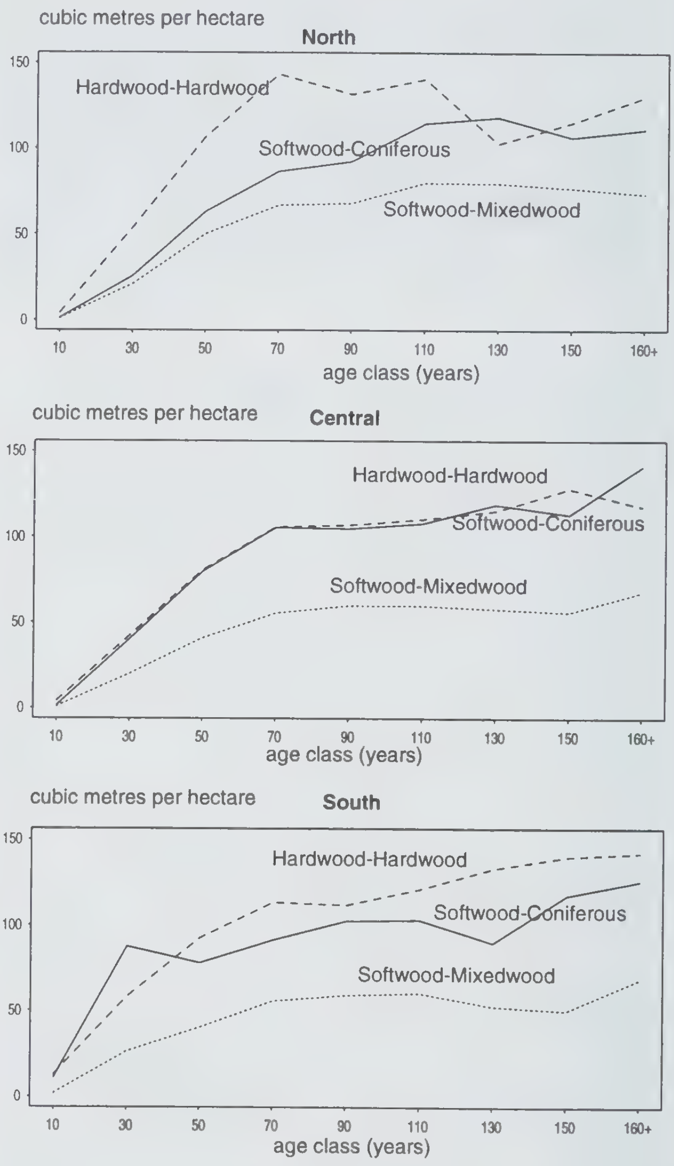
1955-72: Area burned in each of the 22 L&F districts was recorded in the annual statistics. These statistics do not classify the area burned by cover type or land class, assumptions derived from 1951-61 data, were used as stated in the previous section.

1973-91: Data for area burned in each of 8 regions were available. The area burned in the three northern regions were reduced because the extent of forest inventory used by the model is south of the northern boundaries of these regions. This was done by applying a factor to the area burned statistics equal to the total area burned in the intensive and measured zones relative to the regional total, based on a twelve year average (1976-88).

Yield tables

Yield tables establish the yield, usually in volume, which an area of forest normally provides at a given age. Yield tables were created using empirical methods to determine the average volume yield of softwood and hardwood woodtypes for three regions in Ontario (north, central and south) as shown in Figure 4.3. These tables provide the connection between the harvest volume (data) and the area harvested. Volume at individual ages was determined by interpolation of the 20 year age class data using a cubic spline function.

Figure 4.3
Average Volume Per Hectare



Harvesting data

It was difficult to obtain accurate, comprehensive harvest data. Problems included: incomplete time coverage, no coverage of private wood, non-convertible units, no geographic labelling or changing geographic framework, incorrect values from mis-reporting or poor measurement unit conversion, and no specification of method of harvest.

1. Potentially Exploitable Area
2. Coverage = digital map file used by a geographic information system (GIS).

The following principal sources of harvest data were explored: timber management planning annual reports, timber scaling and mill license returns.

Regeneration data

Post fire regeneration is represented by an immediate return of the stock affected to an age class of zero. Post harvest regeneration is predicted based on success rates found by a regeneration survey for the Ontario Independent Forestry Audit (Hearnden, Wilson and Millson, 1992). The regeneration transition matrices shown by tables 4.1 and 4.2 provide success rates for artificially assisted or naturally occurring regeneration. The accuracy of the regeneration-predictions are subject to the assumption that changes in harvesting methods, stock, regeneration method, sites and climatic condition have no effect on regeneration predictions.

Table 4.1
Planting Regeneration Transitions

	Coniferous	Mixedwood	Hardwood
Coniferous	0.440	0.397	0.163
Mixedwood	0.194	0.598	0.208
Hardwood	0.150	0.620	0.230

Table 4.2
Natural Regeneration Transitions

	Coniferous	Mixedwood	Hardwood
Coniferous	0.43	0.411	0.159
Mixedwood	0.21	0.580	0.210
Hardwood	0.07	0.360	0.570

Model validation

Traditional model validation involves devising a test that the model, if false, would fail to pass. If the model fails the test then it must be rejected. If it passes, then a more stringent test should be devised and so on until the degree of validation is satisfied . The model is accepted if it explains all the facts. In other words there is always a degree of subjectivity in model validation in deciding when to stop testing its validity.

In the next section the procedures used for validating the simulation framework are briefly described. A method of reconstructing the forest inventory by backward simulation of the 1991 inventory is outlined. A closeness criterion was determined by comparing the graphed age class distributions for the simulated and actual inventories.

Estimation of 1953 age class distribution by reverse calculation method

It was necessary to establish an initial condition from which to commence the simulation. It was originally intended that the initial condition would be based on the 1953 inventory. Unfortunately, it categorized the forest into broad maturity classes. While an attempt was made to convert the maturity classes into numerical age classes, an age class distribution which would provide an adequate initial condition could not be reached.

As an alternative, the model was rewritten to run in reverse and derive an initial condition from the 1991 inventory. The reconfiguration proved somewhat problematic since many of the processes in the model require a cover type, age class distribution to predict the changes which will take place in a period. For example, the fire losses in any one period are spread amongst the cover types and age classes according to their relative occurrence in a district. The cover type, age classes distribution at the end of year $k+1$ was shifted backwards one year and used as a substitute for the distribution for the beginning of a year k.

Another difference in the reverse-order model is the handling of the fire regeneration. When a fire occurs in the forward stepping model the area burned is placed in the first year age class at the start of the next period. The direct opposite would be to remove all of the area burned from this first age class and distribute it amongst the other ages. In the case of large fires this may not be feasible where there is inadequate area in the first year age class to cover the fire loss. To avoid this difficulty the reverse-order model takes area from all of the first 20 age classes. Since the areas in the single-year age classes were originally taken from an inventory which grouped them into 20 year classes, this is a reasonable solution. These slight differences in the forward and reverse models mean that there are some differences in the original 1991 and the predicted 1991 inventory.

Results

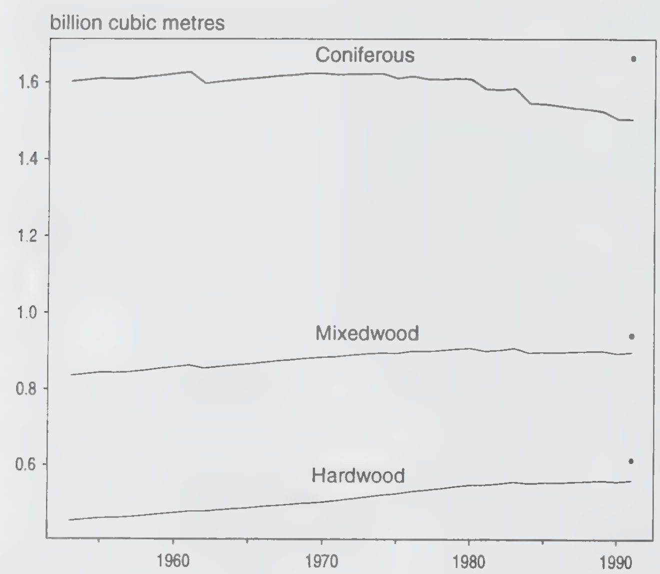
The physical accounts are a series of year end stock data showing the area and volume of forest land as provincial totals. The stock data, which include both the growing stock in cubic metres and the forest land area, are estimated by cover type. The changes to these stocks from year to year and the reasons for this change, such as growth, harvest, natural loss due to fire and mortality, change in land use due to area withdrawn for roads or parks are summarized in the next sections as provincial totals.

Growing stock

One indicator of forest development is total growing stock, calculated as the product of the area of forest and the yield, net merchantable volume per hectare. Yield tables are derived as a function of age for both softwood and hardwood woodtypes specific to the cover type defined. Figure 4.4 shows the total growing stock (cubic metres) by three cover types for the historical period 1953 to 1991. These derived data are the result of simulating the changes to the estimated 1953 inventory over the 38 years which constitute the simulation time horizon.

As can be seen from Figure 4.4 a shortfall of about 200 million cubic metres is predicted for 1991. This results from the prediction of a younger forest with lower volumes per hectare. Also, as discussed in the next paragraph, the predicted forest broken down by cover type is different from the 1991 inventory. More mixedwood cover type area is predicted which has a lower volume per hectare than the coniferous forest type.

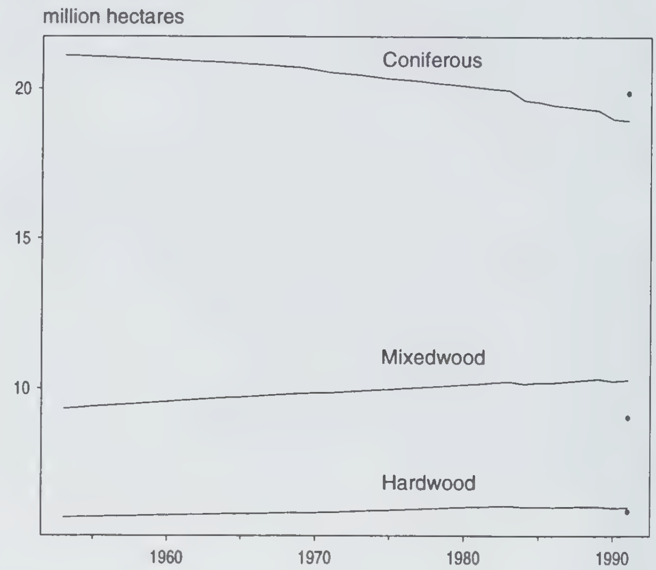
Figure 4.4
Growing Stock by Cover Type



Note:
The points are the 1991 Canada Forest Inventory, Canadian Forest Service.

The stocked forest land area over time, as depicted by Figure 4.5, reveals a discrepancy between the end point of the simulation (1991) with the actual data points for the 1991 inventory. However, the difference between the total 1991 inventory in area and that projected from the model is small. This discrepancy is a result of assuming that forest area burned or died regenerates to the same cover type and that the regeneration transition matrices are not defined on a district basis. These regeneration assumptions will introduce error over time in the distribution of forest land by cover type.

Figure 4.5
Stocked Forest Land Area



Note:
The points are the 1991 Canada Forest Inventory, Canadian Forest Service.

Fire loss

The randomness of forest fires from year to year is seen in Figure 4.6. Catastrophic fires occurred in 1961 and 1980. The variability of these disturbances becomes visible in the age class distribution of the forest originating as large regenerated areas in the first age class as shown by Figure 4.7.

Figure 4.6
Volume Burned

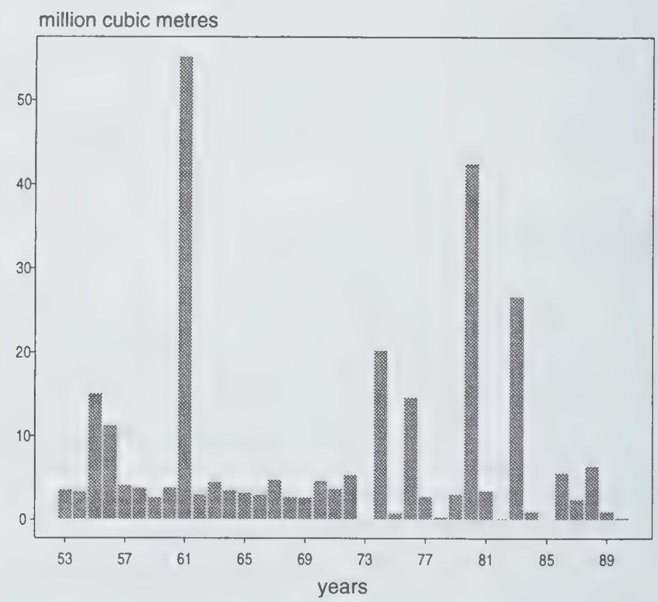


Figure 4.7
Age Class Structure of Forest, 1991

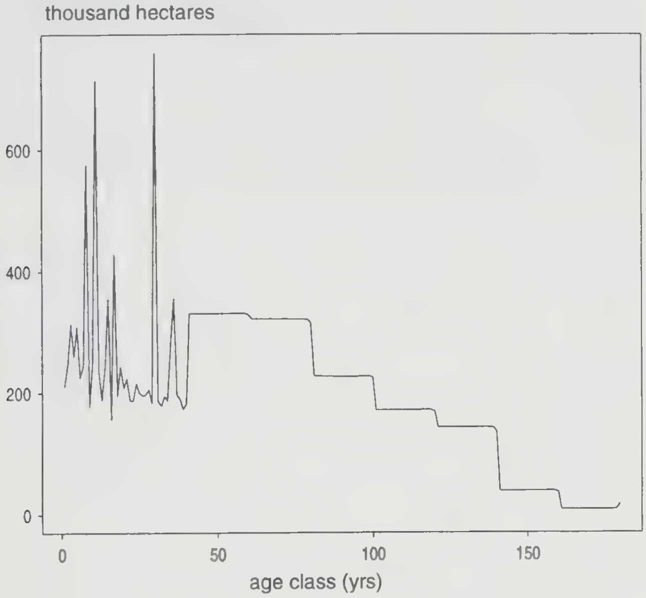
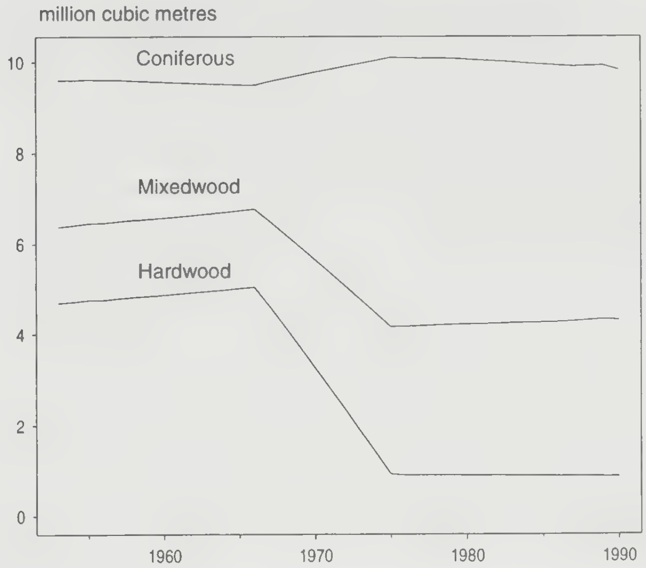


Figure 4.8
Volume Lost to Mortality



Mortality

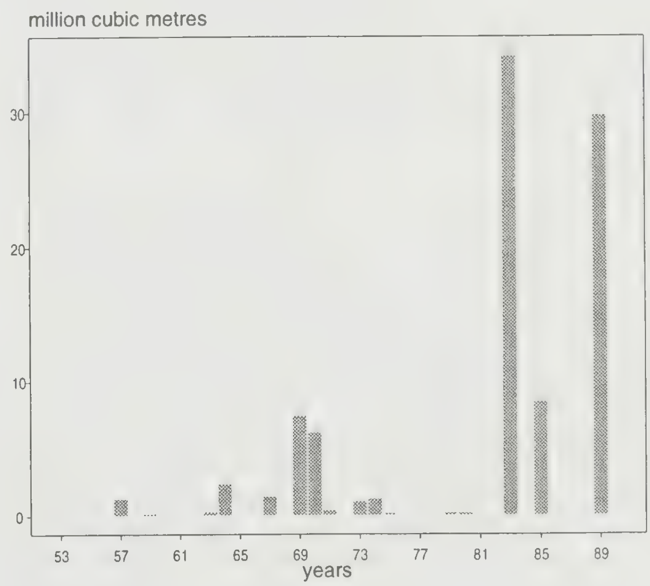
Natural mortality is represented by assuming that the area of the oldest single year age class (180 years) dies. The pattern of mortality seen in Figure 4.8 displays the volume of forest that is lost to mortality over the historical period 1953 to 1991. The drop in mortality for both mixed and hardwood cover types is explained as a result of the way in which the age class structure evolves over time. Since mortality is represented in the model as all area that reaches the oldest age class, discontinuities in the age class structure will be reflected in the shape of the mortality curve.

Discontinuities in the age class structure in this framework arose because a single year age class distribution was created from twenty year age classes. Therefore, these drops in mortality are in part an artefact of the model structure. The abruptness of this effect was smoothed by running the time series through a simple linear time invariant filter (a convolution filter).

Roads and parks

Each year a certain amount of stocked productive forest land is withdrawn from the exploitable landbase. The first withdrawal is the creation of new parks. The second withdrawal is the roads required for harvesting. Three percent of the area harvested was used as the proxy for logging roads. Figure 4.9 shows the volume of forest withdrawn for parks over time. The trend suggests that forest set aside for parks has increased considerably recently.

Figure 4.9
Volume Withdrawn for Parks



Harvesting

As mentioned in the data section of this report, harvesting volume time series for two wood types: softwood and hardwood were reconstructed for the 24 districts from several provincial sources. Figures 4.10 and 4.11 show the provincial total volume and area harvested respectively.

Figure 4.10
Volume Harvested by Woodtype

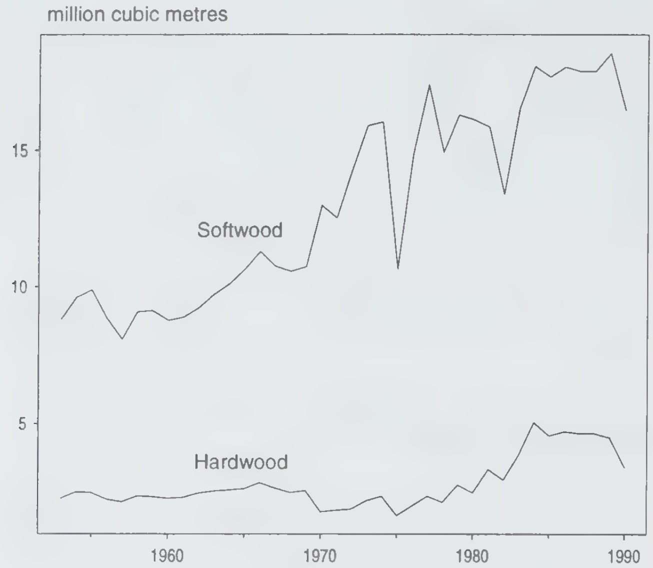
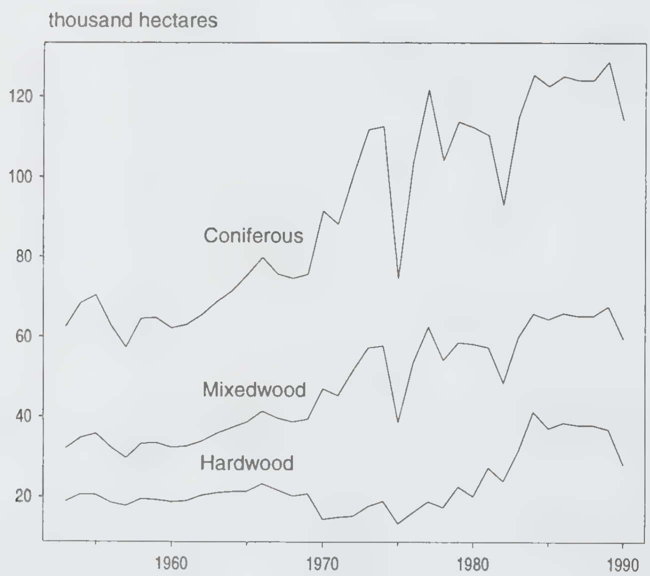


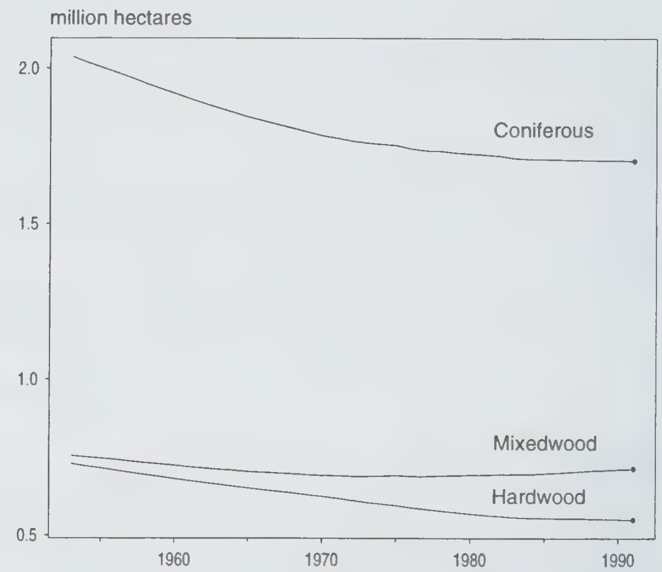
Figure 4.11
Forest Land Area Harvested



Nonstocked forest land

In Figure 4.12 the time path of nonstocked forest land by cover type is shown. A decline in overall nonstocked forest land is seen in Figure 4.12. The points signify the 1991 data points of total provincial nonstocked forest land by cover type. The plotted lines indicate the result of simulating this nonstocked variable over the period 1953 to 1991.

Figure 4.12
Nonstocked Forest Land Area



Timber volume and area account

The physical stock/flow accounting for Ontario net merchantable timber volume is shown in Table 4.3:

Closing Stock = Opening Stock - Volume Lost (due to harvest, fire, mortality and roads and parks withdrawals) + Net Growth.

Where net growth is imputed from the identity:

Net Growth [*k*] = Growing Stock [*k+1*] - Growing Stock [*k*] - Fire Volume Lost [*k*] - Mortality Volume Lost [*k*] - Volume Withdrawn for Roads/Parks [*k*] - Harvest Volume [*k*].

Table 4.3
Ontario Timber Resource Volume Account

Year	Opening stock	Harvest	Fire	Mortality	Parks	Roads	Growth	Closing stock
	thousand cubic metres							
1953	2 892 058	11 081	3 695	20 668	-	332	47 442	2 903 724
1954	2 903 724	12 099	3 464	20 632	-	363	47 509	2 914 675
1955	2 914 675	12 360	15 217	20 720	5	371	47 934	2 913 937
1956	2 913 937	11 083	11 308	20 730	-	332	48 307	2 918 791
1957	2 918 791	10 217	4 253	20 815	1 315	307	48 716	2 930 602
1958	2 930 602	11 434	3 937	20 837	49	343	48 729	2 942 732
1959	2 942 732	11 452	2 839	20 873	232	344	48 927	2 955 919
1960	2 955 919	11 049	3 975	20 909	165	331	49 201	2 968 691
1961	2 968 691	11 187	55 319	20 952	-	336	49 621	2 930 518
1962	2 930 518	11 698	3 096	21 002	-	351	49 523	2 943 895
1963	2 943 895	12 251	4 585	21 055	374	368	49 583	2 954 845
1964	2 954 845	12 684	3 659	21 108	2 465	381	49 612	2 964 160
1965	2 964 160	13 261	3 332	21 162	169	398	49 678	2 975 516
1966	2 975 516	14 127	3 076	21 221	70	424	49 645	2 986 244
1967	2 986 244	13 400	4 847	20 620	1 489	402	49 191	2 994 677
1968	2 994 677	13 059	2 891	19 967	66	392	48 625	3 006 927
1969	3 006 927	13 289	2 777	19 304	7 512	399	47 831	3 011 477
1970	3 011 477	14 759	4 753	18 636	6 260	443	46 666	3 013 292
1971	3 013 292	14 354	3 850	17 954	539	431	48 193	3 024 357
1972	3 024 357	16 169	5 466	17 266	38	485	47 201	3 032 134
1973	3 032 134	18 093	160	16 570	1 159	543	46 058	3 041 667
1974	3 041 667	18 384	20 291	15 868	1 315	552	45 287	3 030 544
1975	3 030 544	12 282	948	15 167	254	368	45 493	3 047 017
1976	3 047 017	16 830	14 766	15 145	131	505	44 491	3 044 131
1977	3 044 131	19 744	2 918	15 153	78	592	43 783	3 049 430
1978	3 049 430	17 064	470	15 165	-	512	44 111	3 060 330
1979	3 060 330	19 051	3 210	15 175	284	572	43 701	3 065 740
1980	3 065 740	18 598	42 588	15 164	280	558	43 706	3 032 258
1981	3 032 258	19 194	3 603	15 152	-	576	43 406	3 037 139
1982	3 037 139	16 323	253	15 140	16	490	43 721	3 048 639
1983	3 048 639	20 393	26 740	15 128	34 238	612	42 507	2 994 035
1984	2 994 035	23 116	1 123	15 112	-	693	41 965	2 995 956
1985	2 995 956	22 244	79	15 100	8 511	667	41 766	2 991 120
1986	2 991 120	22 769	5 771	15 087	-	683	41 541	2 988 350
1987	2 988 350	22 542	2 627	15 074	-	676	41 451	2 988 881
1988	2 988 881	22 542	6 508	15 115	-	676	41 415	2 985 455
1989	2 985 455	23 051	1 169	15 155	29 833	692	40 780	2 956 335
1990	2 956 335	19 872	340	15 032	-	596	41 047	2 961 543

Sources:
Statistics Canada, Canadian Forest Service and Ontario Ministry of Natural Resources.

Finally, the forest land area account is shown in Table 4.4 This states the opening stock in thousand hectares of nonreserved stocked timber productive forest land and the areas harvested, lost to fire and mortality together with area withdrawn from this landbase due to parks and construction of logging roads.

The next column gives the area regenerated due to planting or natural means and the closing stock for nonreserved stocked timber productive forest land. The closing stock of timber productive park land which is also nonreserved and timber productive is shown. The final column provides the closing stock for the nonreserved timber productive forest land which is nonstocked.

Discussion

Forest inventory and timber resource accounting

The primary purpose of the simulation modeling efforts in this project was to estimate a physical, historical time series of Ontario's forest estate. If the estate had been fully inventoried on a regular basis, and all of the changes from both natural events and human interventions were estimated and recorded, simulation would not have been necessary.

The past 30 years has seen the arrival of a number of key technologies for updating and maintaining forest inventories. These new technologies include: computerized databases, satellite imagery, geographic information systems, and global positioning systems. Through the application of these technologies, inventories are becoming more current and comprehensive every year. It is now easy to envision inventory information which is no more than a year or two out of date at anytime.

Original forest inventories in Ontario are currently updated at district and area offices on a five-year recurring basis for the purpose of management planning. Unfortunately, these updated inventories are rarely aggregated back to a provincial level due to differences in standards, computing environments and inventory boundaries. Work on provincial data management and information systems now underway should make provincial compilations simpler and easier.

The 1991 CanFI, used by this project, is compiled on a five year cycle from original provincial forest inventories which are anywhere from 1 to 20 years old. It should be possible to replace the entire Ontario 1991 inventory with a complete, updated inventory for the province on the five year CanFI cycle once the new data management systems are in place. By using CanFI data for resource accounting it will not be necessary to predict more than four years in advance to have annual inventory estimates. This will keep divergence between estimates from the model and the inventory to a minimum.

Change data

The other side of forest resource accounting is tracking the changes which occur to the forest. The compilation of harvest and artificial regeneration statistics is improving in Ontario, with documentation requirements for timber management plans and the environmental assessment driving the process. However, the aggregation of these statistics to a provincial level and the estimation of changes due to natural regeneration, growth, mortality, pest infestations and other natural disasters needs improvement.

The information now available at the provincial level within the National Forestry Database is similar to that required for resource accounting. It would make an excellent starting

Table 4.4

Ontario Timber Resource Area Account

Year	Nonreserved opening stock	Harvest	Fire	Mortality	Parks	Roads	Regeneration	Nonreserved closing stock	Parks closing stock	Nonstocked closing stock
	thousand hectares									
1953	36 144	113	49	169	-	3	361	36 170	915	3 489
1954	36 170	124	47	169	-	4	367	36 194	915	3 461
1955	36 194	127	191	170	-	4	514	36 217	915	3 435
1956	36 217	114	143	170	-	3	455	36 242	915	3 406
1957	36 242	105	57	170	16	3	362	36 253	932	3 376
1958	36 253	117	53	171	1	4	368	36 276	932	3 349
1959	36 276	117	40	171	3	4	355	36 296	935	3 322
1960	36 296	113	54	172	2	3	366	36 318	937	3 295
1961	36 318	115	672	172	-	3	985	36 341	937	3 268
1962	36 341	120	43	171	-	4	359	36 363	937	3 243
1963	36 363	126	62	171	5	4	383	36 378	942	3 219
1964	36 378	130	51	172	30	4	375	36 366	972	3 197
1965	36 366	135	47	172	2	4	375	36 381	974	3 176
1966	36 381	144	44	173	1	4	380	36 395	975	3 158
1967	36 395	137	66	174	19	4	397	36 392	994	3 138
1968	36 392	133	42	175	1	4	370	36 407	995	3 117
1969	36 407	136	40	175	93	4	371	36 330	1 088	3 098
1970	36 330	153	66	176	74	5	410	36 267	1 162	3 082
1971	36 267	148	53	130	7	4	348	36 273	1 168	3 065
1972	36 273	167	73	127	-	5	379	36 280	1 169	3 052
1973	36 280	187	2	127	13	6	324	36 269	1 182	3 044
1974	36 269	189	267	127	15	6	591	36 256	1 197	3 036
1975	36 256	126	11	127	3	4	285	36 269	1 200	3 016
1976	36 269	173	196	127	2	5	507	36 273	1 202	3 005
1977	36 273	203	35	127	1	6	370	36 271	1 203	3 001
1978	36 271	176	6	128	-	5	319	36 275	1 203	2 991
1979	36 275	195	42	128	3	6	371	36 272	1 206	2 985
1980	36 272	191	559	128	3	6	884	36 270	1 209	2 978
1981	36 270	195	49	127	-	6	377	36 270	1 209	2 973
1982	36 270	165	3	127	-	5	307	36 276	1 209	2 961
1983	36 276	206	376	127	447	6	712	35 826	1 657	2 958
1984	35 826	232	15	126	-	7	371	35 817	1 657	2 960
1985	35 817	224	1	126	101	7	350	35 709	1 758	2 960
1986	35 709	229	83	126	-	7	437	35 701	1 758	2 962
1987	35 701	227	34	126	-	7	387	35 693	1 758	2 963
1988	35 693	227	90	127	-	7	443	35 685	1 758	2 964
1989	35 685	233	13	127	390	7	371	35 285	2 148	2 966
1990	35 285	202	5	126	-	6	336	35 283	2 148	2 962

Sources:
Statistics Canada, Canadian Forest Service and Ontario Ministry of Natural Resources.

point and would provide the provinces with a means of making this information available to a wider audience with minimal effort.

Conclusion

The modeling methodology was successful in resolving a time series estimate of the physical stock of Ontario's forest estate over the 38 year historical period. Despite the flexibility of the modeling software considerable effort was required to transform and translate the raw data available into the structures necessary for simulation. In the opinion of the authors, the resolution of the model and its outputs represent the best compromise given the resources and data available.

It is difficult, to ascertain the accuracy and reliability of the estimates generated because of the complexity of the model, the number of assumptions required and the unavailability of additional independent data.

Over the 38 year period the total forest stock increased to 3.07 million cubic metres in 1980 and then declined to 2.98 million cubic metres in 1990. This change in stock level depends on several factors. Evolution of the age class distribution shows a decrease in volume in the older age classes. By 1990 the total growing stock is distributed such that most volume is centred around the 60-year old class.

This young forest has considerable potential for growth because the average volume per hectare is an increasing function with age as seen in Figure 4.3. Therefore the growth rates are greater in the younger age classes.

Glossary

Canada forest inventory. Through the Canadian Forest Inventory Committee, the Canadian Forest Service works in close cooperation with provincial and territorial forest management agencies to make recommendations on forest inventory procedures, and to acquire data for national area and volume summaries on topics such as ownership, status, productivity, site quality, stocking, disturbance, age, forest types and species groups. Data on forest inventories are available from the Forest Inventory and Analysis Project, Canadian Forest Service.

Coniferous cover type contains cone-bearing trees with needle or scale-like leaves belonging to the botanical group Gymnospermae.

Coverage in remote sensing terminology is the overall area covered by overlapping aerial photos or by maps.

Cover type is a group of forested areas or stands of similar composition which differentiates it from other groups.

Endemic mortality due to insects and diseases is mortality reflected in the empirical yield tables.

Empirical yield table is a summary table showing, for stands (usually even-aged) of one or more species on different site qualities the characteristics of the stand at different ages. The characteristics usually include average diameter and height and total basal area, number of trees, and volume per hectare. Empirical tables are prepared for actual average stand conditions.

Growing stock is the sum by number, basal area or volume of trees in a forest or specified part of it.

Hardwood cover type contains trees belonging to the botanical group Angiospermae with broad leaves usually all shed annually.

Limits of operability define the range of ages from which harvesting may occur.

Mixedwood cover type contains an approximately equal mixture of coniferous and hardwood trees.

Multi-dimensional array is the generalization of a matrix. Where matrices have two subscripts, arrays may have one, two, three or more subscripts.

Nonreserved forest land is forest land that, by law or policy, is available for the harvesting of forest crops.

Positive linear system is a linear system in which the state variables are always positive (or at least nonnegative) in value.

Production forest is productive forest land where harvesting may occur.

Productive forest land is forest land that is capable of producing a merchantable stand within a reasonable length of time.

Reserved forest land is not available for the harvesting of forest crops.

Roundwood is the section of tree stems, with or without bark.

Titleset is a collection of character labels which describe the elements in each array dimension.

References

Hearnden, K.W., S.V. Millson and W.C. Wilson, 1992, "A Report on the status of Forest Regeneration", Ontario Ministry of Natural Resources.

Luenberger, D.G., 1979, ***Introduction to Dynamic Systems. Theory, Models, and Applications***, New York: John Wiley & Sons.

Moll, R.H.H., 1992, "A Prototype Forest Resource Accounting System for Ontario: Concepts and Methods." ***Optimum***, 23 (3), p. 78-87.

Ontario Ministry of Natural Resources, 1953, Forest Resource Inventory.

Samuelson, P.A., 1976, "Economics of Forestry in an Evolving Society", ***Economic Inquiry***, 14 (4), p. 466-492.

5 Valuing Ontario's Timber Resource Stock

by Gerry Gravel, Greg Lawrance and Susan Ecclestone

Introduction

This chapter discusses a method used to produce a time series of estimates of the value of Ontario's timber resource stock. The development of timber resource accounts started with an Ontario pilot project, carried out with the assistance of the Ontario Ministry of Natural Resources (OMNR). The pilot project will be extended to other provinces.

The value of resource stocks will be included in Canada's National Balance Sheet Accounts, a part of the Canadian System of National Accounts. Physical and monetary accounts of natural resource assets will show the importance of natural resources relative to the other assets which make up national wealth and the change in value or relative importance over time.

Forest assets in the System of National Accounts

The ***System of National Accounts 1993*** (SNA93), published jointly by the United Nations, the Organization for Economic Cooperation and Development, Eurostat, the International Monetary Fund and the World Bank, is the international standard guide for economic accounts. This recent version recommends that estimates of the value of natural resources be included along with the tangible assets such as buildings and equipment already shown in national balance sheet accounts. The Canadian System of National Accounts will be made compatible with this world standard by 1997. The SNA93 makes a distinction between natural resources and natural assets, where only the latter part is to be included in economic accounts. The natural assets to be included in economic accounts are those resources over which ownership rights have been established and which are commercially exploitable[1]. Remote or protected forests which are inaccessible or where there is no effective right of exploitation are excluded.

Additional information on natural assets is shown in an account called other changes in volume of assets. This account reconciles differences in the value of assets from one year to the next by showing the value of changes due to a number of causes, which, in the case of forests, include growth, depletion through harvest, changes in use or ownership, catastrophic loss and changes in price.

*The **system of integrated environmental and economic accounting*** (SEEA), (United Nations, 1993a), outlines a preliminary version of a more extensive set of environmental accounts that would be satellites to the existing accounts of the SNA. These accounts include physical balances in addition to monetary measures and are based on a definition of natural assets which extends beyond those which are commercially exploitable. Monetary accounts would, in effect, expand what is considered production to include natural growth. The value of timber which is harvested would be recorded as depletion, which would be netted against the value of growth to arrive at a measure of Eco Domestic Product (EDP). Stocks of assets which are not economic assets in the conventional SNA would not be valued in monetary terms, but recorded in physical terms only. Changes in the stocks of these assets, or uses of these assets that degrade their quality, would be valued. Suggested methods of valuation are based on the cost of prevention or of restoration of the degradation. These costs would also be included in the calculation of EDP.

The exact content and structure of the Canadian forest accounts has not been decided yet. The accounts will show the area and volume of the physical stock and changes due to growth and to harvest or other loss. The physical data can cover all forest land, not just what is commercially exploited. Some of the benefits of a forest that could be given a monetary value include the harvesting of timber and other forest products, recreational use, aesthetic benefits, flood protection, prevention of soil erosion, water purification and storage, effect on climate, wildlife habitat and biodiversity. There are currently no generally acceptable methods for valuing all of these benefits.

In this chapter, we consider only the commercially exploitable forest, which we value as a timber resource. The value is based on the net income obtained from harvesting the timber. Other uses of the timberland and remote or protected forest are not valued; estimates of these values would require a different method of valuation.

The physical timber asset

The part of the forest resource that we consider as a natural asset is the accessible land on which timber harvesting is allowed and on which trees of commercially valuable species grow to a merchantable size in a reasonable length of time. The period since 1961 has seen changes in Ontario's timber land base as a result of roadbuilding and changing land use. Technological change in harvesting and wood processing has meant that more of the standing volume could be harvested or used in forest products and that new uses were found for some species. Remote areas have

1. United Nations, 1993a, paragraph 13.53.

been made accessible with roadbuilding and part of the area has been restricted to maintain habitat or prevent erosion. Transportation costs mean that forest which is distant from a mill is not commercially viable until a mill is constructed in its vicinity.

Valuation

To be comparable to other assets in national balance sheet accounts, timber should ideally be shown at market value, the price that would be obtained if the asset were sold in a competitive public market. In the case of timber in Ontario, market transactions rarely take place.

The government of Ontario owns 86 percent of the productive forest land. Rather than selling cutting rights, the government enters into management agreements under which it sets maximum allowable harvest levels, known as the annual allowable cut, based on an assessment of long-run sustainable yield. The provincial government receives revenue in the form of area charges and stumpage fees in return for the wood supply and management services. Since stumpage fees are set by the province rather than determined by public auction, it is difficult to know how closely they reflect the market value of the timber. Many of the buyers of timber have monopsonistic markets (single buyer) due to the relatively high cost of transporting wood to the next nearest mill, so that even a market transaction might not represent a competitive market price.

Rent

The market value of timber determined by public auction is highest bid based on a buyer's calculation of stumpage value, the difference between the eventual selling price of the timber and the cost of bringing it to market. The term stumpage value means, literally, the value of timber 'on the stump' before industrial intervention. The term rent is used more generally to apply to all resources and also refers to the value of the resource itself.

Calculating the stumpage value of a province's timber asset for a long time series is impractical because of the lack of sufficiently detailed historical data. Data would be required for the numerous factors that determine the stumpage value, which include species, size, quality, location (distance from a market), accessibility and the costs of felling.

Instead of calculating a value based on the characteristics of the timber itself, we calculate a rent residual from historical data for annual production by the province's forest product industries. Capital and operating costs incurred by the industry in felling, transporting or processing timber are subtracted from the value of forest products produced. Payment of stumpage or other fees is not considered a cost; these fees are part of the residual. The residual rent estimate is based on harvesting which took place on the timber production land base of the period with available production capacity. The annual rent obtained is the basis for valuation of the timber stock asset.

Net price

A simple valuation technique, with physical data for the volume harvested and for the volume of the total timber asset, would be to use the annual rent to derive an average rent per unit of volume to apply to the total volume. This method, often called net price, is essentially an estimate of the rent that would be obtained if the whole forest were harvested immediately. A refinement of the method would exclude the volume of trees which are too small to be harvested but which are included in the volume data, so that what is calculated is exactly what would be harvested if it were possible to do so. The method is limited in that it ignores the value of trees which are currently small, but which will be harvested in the future when their volume has increased. The assumption that all harvestable timber will be harvested within a short period of time means that what will actually be future rent income is given an undiscounted present value, that is, there is no allowance for time preference.

Present value

Estimating the value of rent from future harvests would require knowledge about future prices, costs and harvest volumes. If the forest is being harvested at a sustainable rate, that is, if the annual allowable cut is determined accurately and is not exceeded, an indefinite number of equivalent future harvests is possible. If we assume that annual rent will be constant, the value of the timber asset as the source of future income can be calculated as the present value of an infinite series of annual rent equal to the current year's rent. Capitalizing a stream of future income by discounting it to a present value is a common method of valuing a financial asset such as a bond, which yields interest annually or semiannually. The difference is that the bond's yield is known, but the rent actually to be obtained from the timber is not. Use of this method to value timber raises questions about the validity of assuming constant rent and about the choice of an appropriate discount rate.

The selling prices of forest products are cyclical and this is reflected in the rent residual. Rather than capitalizing each year's rent individually, we use a moving average to reduce cyclical volatility. In other words, we assume that future rent will be similar to current average experience. Discounting future income limits the effective length of time during which rent is assumed to be constant; a 5 percent discount rate gives a near zero present value to income earned after about fifty years (a 10 percent rate would reduce this time to twenty years).

The question of which discount rate to use is difficult to answer conclusively. It could be argued that the discount rate should reflect a social time preference because the rent is, to a great extent, potential revenue of the province which

owns the resource. The rate used to discount future rent income should be seen as a real rate, that is, there is no inflation to discount since we assume constant future prices and costs. We use more than one rate to show the effect of the discount rate on asset values. One of the rates used, 4 percent, is an estimated average real provincial government borrowing rate for the period 1961 to 1991.

Timber and land

Both SNA93 and the SEEA classify timber separately from the land it grows on. While it is easy to distinguish between timberland and the timber on it in physical accounts, it is difficult to value them separately.

The value calculated on the basis of future harvest rent income is a return both to the timber resource and to the land it occupies, since the land must be devoted to growing timber. Use of the land for timber production does not necessarily or always exclude some other uses such as wildlife habitat or human recreation. These other uses of the land or timber could also have economic value which could be added to the value of the asset, although whether the asset is land or forest is again ambiguous. It is questionable whether much of the timberland really could have a different use. Some timberland is too remote to be sold as a building site and unsuitable for agriculture. We do not try to separate timber value from land value.

The question of land ownership and timber production is a further consideration in the value of the timber asset. The forest management expenses incurred by the government in maintaining the timber asset are considered a cost to be netted from the rent. An additional reason to consider public forest management expenditure is consistency among the eventual data series for all provinces. The share of total forest management expenditures borne by government varies among provinces and changes over time. For example, the responsibility for expenditure on reforestation in Ontario has recently shifted from government to industry. Both private and public forest management expenditures are considered.

The calculation of asset value

Industry surplus

The selling price and cost data required to calculate annual rent are available for the logging industry. However, a large number of the logging establishments which report the data are part of integrated firms. These establishments do not actually sell timber to their parent mills, so that the selling prices reported do not necessarily reflect market prices for timber. If the reported selling price were too low, part of the rent would, in effect, be shifted to the buyer of the timber, so that a rent calculation based on the logging industry alone would be understated. Similarly, a high reported price would overstate the actual rent. To avoid the problem, we calculate rent for an industry group consisting of both the logging establishments and the secondary wood processing industries which sell their output in public markets. These secondary industries are pulp and paper mills, veneer and plywood and sawmilling and planing.

The value of production is based on data for value of shipments and changes to inventory from the Statistics Canada publications ***Logging Industry*** (Cat. No. 25-201), ***Sawmilling and Planing*** (Cat. No. 35-204) and ***Pulp and Paper Mills*** (Cat. No. 36-204). The value of wood cut by consumers for own consumption (primarily firewood and some sawn wood) is not estimated.

Statistics on operating costs such as labour, fuel and electricity, materials and supplies (but excluding stumpage fees) for the logging industry were taken from ***Logging Industry*** (Statistics Canada, Cat. No. 25-201). Similar statistics for the sawmilling, pulp and paper and veneer and plywood industries were taken from ***Canadian Forestry Statistics*** (Statistics Canada, Cat. No. 25-202).

Capital costs include both a consumption allowance (depreciation) and the cost of financing the net capital investment. Capital consumption allowances and end-of-year net capital stock measures by industry are prepared by Statistics Canada's Investment and Capital Stock Division. Capital stock estimates are at replacement cost. Depreciation is straight line over a life of thirteen years. The cost of financing capital is a nominal average corporate long-term bond rate (data from Scotia McLeod published in the ***Bank of Canada Review***) applied to the value of the capital stock. No allowance is made for profit; the borrowing cost is applied to the total capital stock, whether financed by debt or by equity, so that there is some return to equity included.

The annual value of rent generated in the logging industry (SIC 0410) is shown in Table 5.1. The logging industry has consistently been profitable over the period studied, but this could reflect pricing of sales to cover costs by establishments which are integrated with mills. The cost of capital averages 3 percent of the industry's total costs.

The annual values of production for the wood industries (sawmilling, planing, veneer & plywood) are presented in Table 5.2. The sawmill and planing industry (SIC 2510) and veneer and plywood industry (SIC 2520) were aggregated to protect confidential data in the veneer and plywood industry. Capital costs averaged about 11 percent of total costs.

Table 5.1
Logging Industry Production Surplus

Year	Costs: Operating	Costs: Capital	Costs: Total	Value of production	Surplus
	millions of current dollars				
1961	104.5	10.9	115.4	135.3	19.9
1962	106.4	11.0	117.4	137.8	20.4
1963	111.1	11.3	122.4	143.9	21.5
1964	115.4	11.7	127.1	147.2	20.1
1965	129.1	12.7	141.8	164.3	22.5
1966	149.0	14.2	163.2	195.5	32.3
1967	168.1	15.8	183.9	211.0	27.1
1968	150.0	16.4	166.4	192.3	25.9
1969	169.1	18.1	187.2	215.2	28.0
1970	172.6	18.5	191.1	215.0	23.9
1971	163.7	18.7	182.4	205.3	22.9
1972	182.2	19.1	201.3	228.0	26.7
1973	208.3	22.0	230.3	266.1	35.8
1974	263.1	30.5	293.6	348.4	54.8
1975	253.6	36.8	290.4	334.0	43.6
1976	274.1	37.7	311.8	359.8	48.0
1977	332.7	41.2	373.9	430.2	56.3
1978	415.2	45.2	460.4	511.3	50.9
1979	491.6	52.6	544.2	599.8	55.6
1980	571.1	62.6	633.7	706.1	72.4
1981	612.4	78.7	691.1	731.1	40.0
1982	547.0	71.9	618.9	662.6	43.7
1983	633.5	68.1	701.6	786.9	85.3
1984	790.0	66.0	856.0	952.8	96.8
1985	764.3	61.8	826.1	937.8	111.7
1986	809.5	61.0	870.5	1 033.5	163.0
1987	771.1	61.0	832.1	987.2	155.1
1988	913.6	60.4	974.0	1 206.3	232.3
1989	1 006.8	59.5	1 066.3	1 300.1	233.8
1990	937.7	61.9	999.6	1 165.5	165.9
1991	854.3	55.7	910.0	1 065.0	155.0

Sources:
Statistics Canada, National Accounts and Environment Division, Industry Division and Investment and Capital Stock Division.

Table 5.2
Wood Industries Production Surplus

Year	Costs: Operating	Costs: Capital	Costs: Total	Value of production	Surplus
	millions of current dollars				
1961	64.2	6.5	70.7	79.2	8.5
1962	71.4	6.8	78.2	88.5	10.2
1963	78.3	7.1	85.4	98.9	13.5
1964	85.1	7.6	92.7	110.3	17.6
1965	89.1	8.8	97.9	120.7	22.8
1966	102.0	9.9	111.9	129.8	17.9
1967	105.0	10.7	115.7	131.0	15.3
1968	115.2	11.3	126.5	142.6	16.1
1969	121.0	14.1	135.1	151.8	16.7
1970	114.2	15.4	129.6	134.0	4.4
1971	120.7	15.9	136.6	147.6	11.0
1972	137.4	17.8	155.2	185.8	30.6
1973	173.5	22.9	196.4	260.8	64.4
1974	198.6	35.0	233.6	267.0	33.4
1975	204.8	41.4	246.2	240.4	-5.8
1976	235.1	41.6	276.7	277.8	1.1
1977	287.1	45.8	332.9	349.7	16.8
1978	363.8	52.7	416.5	486.5	70.0
1979	460.1	63.6	523.7	623.5	99.8
1980	521.2	77.2	598.4	620.6	22.2
1981	556.8	95.7	652.5	645.5	-7.0
1982	489.5	87.1	576.6	538.0	-38.6
1983	608.5	90.0	698.5	733.0	34.5
1984	709.2	90.9	800.1	827.2	27.1
1985	797.5	81.8	879.3	947.8	68.5
1986	854.2	80.4	934.6	1 019.2	84.6
1987	875.8	84.0	959.8	1 014.7	54.9
1988	967.9	90.4	1 058.3	1 116.7	58.4
1989	976.5	89.5	1 066.0	1 095.9	29.9
1990	893.4	90.2	983.6	969.5	-14.1
1991	793.6	77.2	870.8	864.9	-5.9

Sources:
Statistics Canada, National Accounts and Environment Division, Industry Division and Investment and Capital Stock Division.

The pulp and paper industry production surpluses are presented in Table 5.3. Capital costs are significantly higher than in the other forest industries, averaging more than 18 percent of total costs. The surpluses and deficits exhibited by the pulp and paper industry dominate the forest industries as a whole. The importance of its surplus or deficit relative to the rest of the industry raises some questions about just what is captured in the residual. For example, rent could be dissipated by inefficient producers.

Forest management expenditure

Forest management expenditures fund activities such as maintenance of a forest inventory, planning, access provision, fire protection and reforestation or other silvicultural activities. Data available for forest management expenditure by government apply to more than just the timber-producing part of the forest, so that an allocation must be estimated.

The Ontario Ministry of Natural Resources (OMNR) recently contracted an accounting firm to review the ministry's financial reporting and develop accounting methods which would determine the cost of protection and renewal to be recovered in the price of resources. The ***Forest Management Accounting Framework***, published in 1993 as the result of the study, indicates the part to be allocated to timber supply of expenditures made in the four broad categories administration, aviation and fire protection, resource access and forest management. These ratios were applied to historical data from ministry annual reports. Despite the broad categories, changes in reporting format result in a less than perfectly continuous series of estimates over time.

Table 5.3

Pulp, Paper and Allied Industries Production Surplus

Year	Costs: Operating	Costs: Capital	Costs: Total	Value of production	Surplus
	millions of current dollars				
1961	352.3	48.9	401.2	479.2	78.0
1962	365.7	49.7	415.4	509.8	94.4
1963	375.0	51.9	426.9	521.9	95.0
1964	398.5	58.2	456.7	555.9	99.2
1965	412.6	70.9	483.5	577.9	94.4
1966	457.8	82.9	540.7	631.7	91.0
1967	478.2	90.5	568.7	631.1	62.4
1968	505.4	91.7	597.1	648.7	51.6
1969	547.3	103.5	650.8	718.8	68.0
1970	583.5	109.4	692.9	736.2	43.3
1971	588.3	116.0	704.3	727.2	22.9
1972	627.6	124.1	751.7	780.3	28.6
1973	701.6	139.4	841.0	916.3	75.3
1974	906.1	186.5	1 092.6	1 383.6	291.0
1975	756.4	225.0	981.4	1 044.9	63.5
1976	1 026.6	251.3	1 277.9	1 251.8	-26.1
1977	1 305.2	280.7	1 585.9	1 612.2	26.3
1978	1 458.7	312.7	1 771.4	1 787.5	16.1
1979	1 723.7	378.3	2 102.0	2 260.3	158.3
1980	1 925.0	453.0	2 378.0	2 644.8	266.8
1981	2 155.5	628.4	2 783.9	2 890.4	106.5
1982	2 149.9	654.8	2 804.7	2 631.1	-173.6
1983	2 316.1	686.3	3 002.4	2 776.7	-225.7
1984	2 559.5	692.8	3 252.3	3 398.4	146.1
1985	2 619.9	671.0	3 290.9	3 388.4	97.5
1986	2 718.5	688.8	3 407.3	3 679.1	271.8
1987	2 934.7	722.7	3 657.4	4 288.6	631.2
1988	3 055.4	764.4	3 819.8	4 665.1	845.3
1989	3 185.6	853.1	4 038.7	4 672.1	633.4
1990	3 226.5	983.5	4 210.0	4 358.7	148.7
1991	2 926.6	912.3	3 838.9	3 441.1	-397.8

Sources:
Statistics Canada, National Accounts and Environment Division, Industry Division and Investment and Capital Stock Division.

The timber supply expenditure estimates for the period 1961 to 1991 are presented in Table 5.4. While all categories increased over this period the forest management category has undergone the largest escalation, due in particular to regeneration efforts. Some of the expenditure in the early 1980s may be attributable to the treatment of a backlog of land left previously untreated. The cost of fire control is also variable and again, the variation is not closely related to current harvest volumes. No attempt is made to reassign costs by prorating reforestation or fire control expenditure based, for example, on the area harvested.

The category 'resource access' covers only the maintenance costs for logging roads; expenditure on their construction is included in the category of 'forest management'. Isolating the expenditure on permanent roads would be desirable, so that it could be treated as capital, that is, the cost could be amortized over the life of the asset rather than treated as an expenditure in the year it is purchased.

Table 5.4

Government Timber Supply Expenditure

Year	Administration	Aviation and fire	Resource access	Forest management	Total
	millions of current dollars				
1961	1.5	2.6	-	6.0	10.1
1962	1.6	2.1	-	6.2	9.9
1963	2.1	2.2	-	7.4	11.7
1964	2.3	2.2	0.4	7.8	12.8
1965	2.5	2.2	0.4	8.2	13.3
1966	3.3	2.7	0.4	11.2	17.5
1967	3.4	3.1	0.8	12.8	20.1
1968	3.7	3.1	0.9	14.9	22.6
1969	3.6	3.3	0.6	13.6	21.1
1970	4.0	4.2	0.8	14.9	23.9
1971	3.9	4.2	0.7	19.3	28.1
1972	9.3	4.1	0.8	20.8	34.9
1973	10.1	3.6	3.3	29.8	46.8
1974	11.2	6.8	5.4	24.9	48.3
1975	13.5	6.7	5.7	31.0	56.9
1976	14.8	11.3	2.7	36.3	65.2
1977	15.7	8.8	2.6	43.2	70.4
1978	17.2	6.4	2.5	49.7	75.8
1979	18.6	8.5	2.9	56.8	86.8
1980	19.5	18.9	2.5	71.5	112.4
1981	26.5	17.1	2.3	80.4	126.3
1982	30.0	11.9	2.3	89.4	133.7
1983	32.6	16.2	2.3	112.6	163.7
1984	33.8	12.6	2.0	143.0	191.4
1985	33.7	13.2	2.1	157.3	206.3
1986	37.3	20.4	2.0	195.1	254.9
1987	40.8	22.6	2.1	192.1	257.6
1988	42.8	29.3	2.3	186.8	261.2
1989	44.5	21.9	2.3	197.4	266.2
1990	47.7	24.2	3.6	214.4	289.9
1991	33.9	33.8	3.6	214.4	285.6

Source:
Ontario Ministry of Natural Resources.

Aggregate surplus and resource rent

The value of the aggregate surplus for all industries is shown in Table 5.5. Negative values occur in 1982, 1983 and 1991. Subtracting the government's forest management expenditures gives negative rent in 1976, 1981 and 1990 as well. Rent should not be negative, since there would be no exploitation of a resource if the selling price did not cover the exploitation costs.

In part, the negative values are the result of the slightly myopic view imposed by an annual series. Averaged over a longer period of time, rent is positive. The effect of decreased prices and demand on rent can be exaggerated by the methodology used. Capital is depreciated annually, not according to the volume of production. The capital cost per unit increases if the amount produced decreases, that is, generally when demand and prices fall and the rent residual is already reduced. One of the effects of averaging is to amortize capital costs over a longer period, so that it applies to a more typical volume of production. Averaging can also

Table 5.5

Aggregate Industry Surplus and Rent

Year	Costs	Value of production	Surplus	Timber expenses	Rent Annual	Rent Deflated	Rent Averaged
	millions of dollars						
1961	587.3	693.7	106.4	10.1	96.3	398.1	455.8
1962	611.0	736.0	125.0	9.9	115.0	469.6	459.9
1963	634.7	764.7	130.0	11.7	118.2	472.9	457.4
1964	676.6	813.4	136.8	12.8	124.0	482.6	433.8
1965	723.3	862.9	139.6	13.3	126.2	476.4	410.7
1966	815.8	957.0	141.2	17.5	123.7	444.8	385.3
1967	868.3	973.1	104.8	20.1	84.7	292.1	338.5
1968	890.1	983.6	93.5	22.6	70.9	236.4	281.6
1969	973.1	1 085.8	112.7	21.1	91.6	291.8	233.9
1970	1 013.6	1 085.2	71.6	23.9	47.7	145.5	217.5
1971	1 023.4	1 080.1	56.7	28.1	28.7	84.6	281.8
1972	1 108.2	1 194.1	85.9	34.9	51.0	142.3	261.0
1973	1 267.7	1 443.2	175.5	46.8	128.6	329.9	208.0
1974	1 619.8	1 999.0	379.2	48.3	330.9	742.0	194.6
1975	1 517.9	1 619.3	101.4	56.9	44.5	90.8	197.0
1976	1 866.4	1 889.4	23.0	65.2	-42.2	-79.1	225.8
1977	2 292.6	2 392.1	99.5	70.4	29.1	51.4	227.4
1978	2 648.3	2 785.3	137.0	75.8	61.1	101.9	123.7
1979	3 170.0	3 483.6	313.6	86.8	226.8	343.6	61.6
1980	3 610.1	3 971.5	361.4	112.4	249.0	341.1	31.2
1981	4 127.5	4 267.0	139.5	126.3	13.1	16.2	35.7
1982	4 000.1	3 831.7	-168.4	133.7	-302.1	-343.7	31.6
1983	4 402.4	4 296.6	-105.8	163.7	-269.5	-292.0	20.3
1984	4 908.4	5 178.4	270.0	191.4	78.6	82.5	51.2
1985	4 996.3	5 274.0	277.7	206.3	71.4	73.1	162.9
1986	5 212.4	5 731.8	519.4	254.9	264.5	264.5	290.4
1987	5 449.3	6 290.5	841.2	257.6	583.6	557.4	333.4
1988	5 852.2	6 988.1	1 135.9	261.2	874.8	798.1	259.0
1989	6 170.9	7 068.1	897.2	266.2	631.0	549.2	290.0
1990	6 193.2	6 493.7	300.5	289.9	10.6	9.0	295.1
1991	5 619.8	5 371.0	-248.8	285.6	-534.4	-438.4	229.5

Sources:
Statistics Canada, National Accounts and Environment Division, Industry Division, Investment and Capital Stock Division and Ontario Ministry of Natural Resources.

help smooth some of the annual variation in other expenditures, such as fire control.

The rent series was averaged using a seven-year centred moving average after being converted to constant 1986 dollars using the GDP implicit price index. The seven year period is based on a study of residual timber value completed for the OMNR which estimated business cycle lengths of six or ten years for different forest industries (OMNR, 1993a). The averaged series is always positive, although the value is very low in the early eighties.

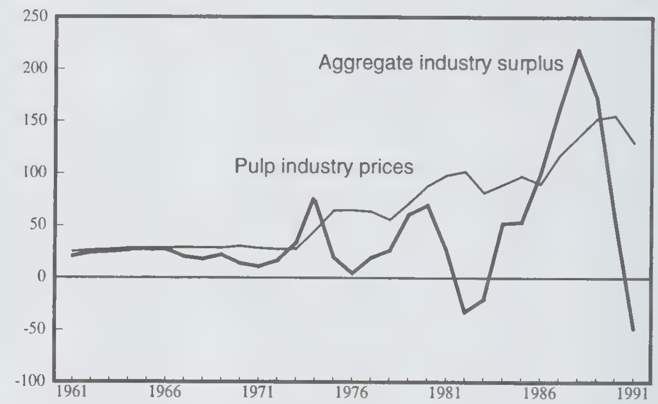
By 1991, in nominal value, current expenditure increased about nine times over its 1961 value, capital expenditure about ten times and government expenditure on timber supply almost twenty-five times. At the start of the series, timber supply expenditure was equivalent to about 2 percent of the forest products industries' total expenditure. It reached 5 percent by 1991.

Stock values

Table 5.6 presents a number of estimates of the value of the resource stock. Estimates are made in both constant 1986 dollars and in current dollars.

Figure 5.1

Indexes of Industry Surplus and Pulp Prices (1986 =100)



Sources:
Statistics Canada, National Accounts and Environment Division and Prices Division.

Two methods are used to calculate present value series of timber stock values in constant 1986 dollars. The columns labelled 'projected rent' are calculated by dividing the current average resource rent by the discount rate, based on the assumption that the current rent will be obtained for an indefinite number of years. The picture of the asset that this presents is its value based on the accessible timber and harvest and production technology of the era. Future harvest volumes, costs and prices do not change. Current experience is projected forward into a future limited by the value of the discount rate.

For comparison, the column labelled 'actual rent' is the sum of the discounted series of calculated future rents shown in the first column, labelled 'averaged deflated rent'. For example, the value calculated for 1961 under 'actual rent' is the sum of the values shown under 'averaged deflated rent' for 1962 onward, discounted to a 1961 value (the last year's averaged deflated rent is used to extend the series into the future to a time where its discounted value is insignificant).

The values for the two different methods converge as the series summation becomes more dependent on the extended value of the last year's rent. The change from actual to projected rent is inconsistent, so that the series cannot be used as the estimate of the value of the asset. However, using actual rent gives a 'perfect knowledge of the future' version of the value estimate, for at least part of the series, which can be compared to the estimate made by projecting current rent. The perfect knowledge series seems to indicate that the exceptionally gloomy outlook of the early

Table 5.6
Estimates of Timber Stock Value

	Averaged	NPV			Net price				NPV		Net price
	deflated	Projected rent		Actual rent	Harvest	Unit	Inventory	Inventory	Projected rent		Inventory
Year	rent	2 percent	4 percent	4 percent	volume	price	volume	value	2 percent	4 percent	value
	millions of 1986 dollars or millions of cubic metres								millions of current dollars		
1961	455.8	22 790	11 395	6 469	11.0	41.25	1 322	54 534	5 671	2 835	13 569
1962	459.9	22 996	11 498	6 272	11.2	41.11	1 301	53 485	5 799	2 899	13 487
1963	457.4	22 870	11 435	6 063	11.7	39.10	1 306	51 066	5 863	2 931	13 091
1964	433.8	21 689	10 845	5 848	12.3	35.41	1 310	46 386	5 630	2 815	12 041
1965	410.7	20 534	10 267	5 648	12.7	32.38	1 313	42 513	5 449	2 724	11 281
1966	385.3	19 264	9 632	5 463	13.3	29.05	1 316	38 235	5 281	2 641	10 482
1967	338.5	16 925	8 463	5 296	14.1	23.96	1 318	31 581	4 778	2 389	8 915
1968	281.6	14 082	7 041	5 170	13.4	21.02	1 319	27 722	4 097	2 048	8 065
1969	233.9	11 696	5 848	5 095	13.1	17.91	1 322	23 682	3 559	1 779	7 206
1970	217.5	10 875	5 438	5 065	13.3	16.37	1 321	21 621	3 595	1 797	7 146
1971	281.8	14 089	7 044	5 050	14.8	19.09	1 318	25 162	5 353	2 677	9 561
1972	261.0	13 049	6 524	4 970	14.4	18.18	1 322	24 036	5 164	2 582	9 513
1973	208.0	10 400	5 200	4 908	16.2	12.86	1 327	17 070	4 209	2 104	6 908
1974	194.6	9 728	4 864	4 896	18.1	10.75	1 332	14 323	4 076	2 038	6 001
1975	197.0	9 851	4 926	4 898	18.4	10.72	1 327	14 221	4 308	2 154	6 219
1976	225.8	11 289	5 644	4 897	12.3	18.38	1 337	24 577	5 564	2 782	12 113
1977	227.4	11 369	5 685	4 867	16.8	13.51	1 336	18 050	6 424	3 212	10 198
1978	123.7	6 185	3 093	4 834	19.7	6.27	1 337	8 377	4 154	2 077	5 625
1979	61.6	3 082	1 541	4 904	17.1	3.61	1 342	4 847	1 678	839	2 639
1980	31.2	1 561	781	5 038	19.1	1.64	1 342	2 200	54	27	76
1981	35.7	1 784	892	5 208	18.6	1.92	1 325	2 541	407	204	580
1982	31.6	1 578	789	5 381	19.2	1.64	1 329	2 185	481	240	666
1983	20.3	1 013	506	5 565	16.3	1.24	1 337	1 659	750	375	1 229
1984	51.2	2 558	1 279	5 767	20.4	2.51	1 312	3 291	3 140	1 570	4 040
1985	162.9	8 143	4 071	5 947	23.1	7.05	1 312	9 243	9 294	4 647	10 551
1986	290.4	14 520	7 260	6 022	22.2	13.06	1 308	17 077	15 960	7 980	18 769
1987	333.4	16 670	8 335	5 972	22.8	14.64	1 305	19 109	17 961	8 980	20 588
1988	259.0	12 949	6 475	5 877	22.5	11.49	1 302	14 959	13 582	6 791	15 690
1989	290.0	14 499	7 249	5 854	22.5	12.86	1 297	16 684	15 251	7 626	17 550
1990	295.1	14 753	7 376	5 798	23.1	12.80	1 281	16 397	15 656	7 828	17 401
1991	229.5	11 474	5 737	5 735	19.9	11.55	1 281	14 792	12 275	6 137	15 825

Source:
Statistics Canada, National Accounts and Environment Division.

1980s that results from the projection of current experience was unwarranted. But then, not all of the actual values are in yet.

The importance of the discount rate is evident in the difference in value obtained by using rates of 2 and 4 percent. Doubling the rate halves the present value.

Table 5.6 also presents the timber stock values estimated using a net price or per-unit rent. Rent per unit of volume is calculated by dividing the averaged annual rent by the annual harvest volume. This rent per unit is applied to the volume of mature timber in the forest inventory estimate for that year. The estimate of volume is obtained from the physical forest account described in chapter four.

As mentioned earlier, the net price method is not expected to give an approximation of market price because it equates present and future value and because it ignores the young part of the forest. The values it gives are nonetheless interesting, since they tell a similar story in a more dramatic way with a larger decline in value from the beginning to the end.

The change in value of the asset (the constant 1986 dollar series drops to one quarter of its starting value by the end of the series) is due entirely to a change in the rent per unit; the volume of mature timber is fairly constant. While the per-unit rent in 1991 is only one quarter of the 1961 rent, the harvest volume has doubled. As a result, the total rent actually generated in 1991 is about one half of that generated in 1961. The present value series based on projected rent end at about half of their 1961 starting values, since they are based on total rent.

Some factors which contribute to the decline in per-unit rent are competition from low-cost sources of pulp fiber and the increasing use of less valuable species as new products or technologies allow their use. The increase in government timber supply expenditure is a significant part of the rent residual. Part of the increase in the harvest volume is a reflection of the increased use of formerly unused species.

The three right-hand columns of Table 5.6 show the current dollar values of the timber stock that would actually appear on the balance sheet.

Conclusion

For use in balance sheet accounts, a present value method is preferable to a net price approach. The present value is an approximation of market value and provides a better measure of timber as an income producing asset.

If we consider other accounts, such as the other changes in volume of assets, the argument for using present value is perhaps even stronger. Change in volume or stock-flow reconciliation accounts measure the change in the value of an asset. For timber, an attempt would be made to value growth and loss due to harvest or fire independently. These changes and a revaluation of the remaining stock account for the change in the value of the stock from one year to another. While the two methods would give a similar value for timber harvested, there could be a large difference for the value of growth or of timber lost to fire. The volume increase of a tree nearing harvest age has a higher present value than an equivalent increase in younger trees. The age and location of trees lost to fire is significant. If the trees are very young, there may be no effect on the value of future harvests at all. While this argues for a present value approach, it is evident that detailed knowledge of the physical inventory of the forest is necessary to be able to estimate values of loss and growth. To some extent, this data problem is solved by forest management practice. Fire loss or insect damage, for example, are risks taken into consideration when calculating allowable cut. In this case, only an unusual fire would have any effect on harvest levels; that is the annual allowable cut would be changed.

The time series of timber asset values based on projected current rent cannot assess sustainability in the sense of providing information about the future. The future is assumed to be like the present. Comparing the value of growth with harvest and other loss is a frequently suggested indicator of sustainability. The quality of such an indicator is questionable unless, as we said above, the value of loss is based on detailed physical data. The mature volume of the forest is perhaps a better rough indicator of sustainability than a monetary indicator would be.

References

Canadian Council of Forest Ministers, 1993, ***Compendium of Canadian Forestry Statistics***, National Forestry Database.

Copithorne, Lawrence, 1979, ***Natural Resources and Regional Disparities***, Economic Council of Canada, Ottawa.

Davis, K.P., 1966, ***Forest management: regulation and valuation,*** McGraw Hill, New York.

Landefeld, J.S. and Hines J.R., 1985, "National Accounting for Non-Renewable Natural Resources in the Mining Industries", ***Review of Income and Wealth***, 31.

Ontario Ministry of Natural Resources (OMNR), 1993a, ***Quantification of residual timber values - northern model***, Ontario.

_____, 1993b, ***Forest Management Accounting Framework***, Ontario.

_____, 1993c, ***Developing a New Timber Production Policy***, Ontario.

Samuelson, Paul, 1976, Economics of forestry in an evolving society, ***Economic Inquiry***, 14 (4), p. 466-492.

Statistics Canada, ***Industry Price Indexes***, Cat. No. 62-011, Ottawa.

United Nations, 1993a, ***SNA Handbook on Integrated Environmental and Economic Accounting***, Statistical Office of the United Nations, Series F#61, New York.

_____, 1993b, Commission of the European Communities-Eurostat, International Monetary Fund, Organization for Economic Co-operation and Development and World Bank, ***System of National Accounts,*** ST/ESA/STAT/SER.F/2/Rev.4, New York.

World Resources Institute, 1991, ***Accounts Overdue: Natural Resource Depreciation in Costa Rica,*** San José and Washington.

6 Quantity and Value of Canada's Coal Reserves

by Alice Born, Marcia Santiago and Véronique Dumas

Introduction

The value of Canada's national wealth is measured in the National Balance Sheet Accounts. Wealth, as it is currently measured on the balance sheet, is the value of the economy's tangible assets such as buildings, residential and agricultural land and machinery and equipment.

However, our wealth is currently being understated since the available wealth statistics do not include the value of our natural assets such as mineral reserves, timber stocks, fish stocks, parkland, etc. These natural assets are being treated as "free gifts" of nature in the current System of National Accounts (SNA) since no entries are included in the asset accounts or production accounts. By excluding the value of natural resources in the SNA, there is no way of measuring how rapidly we are depleting our natural resource stocks or more generally, whether we are maintaining our *total* capital base, both produced and natural.

The new international SNA standard approved in 1993 recommends that the national balance sheet be expanded to include natural resources. Statistics Canada proposes to include the dollar value of Canada's natural resources in the National Balance Sheet Accounts by 1997. Towards that end, estimates of Canada's natural resources are being developed. This chapter provides preliminary estimates of Canada's coal reserves in physical and monetary terms.

Other accounts have been completed for Canada's oil and natural gas reserves and timber stock in Ontario (Born, 1992; Smith, 1995; Moll and Lawrance, 1995; and Gravel *et al.*, 1995). Work is in progress on accounts for metals and other minerals.

Coal in the Canadian economy

Coal is an important mineral to the Canadian economy. It is a fuel that is used in the production of electricity and it will be running many of Canada's power stations into the next century. Today, about 15 percent of Canada's electricity is generated from coal. Coal is also used in the production of steel, tars and chemicals, and in industrial processes such as cement and glass-making.

Canada's coal production and exports have increased steadily in the 1970s and 1980s. In 1991, Canada was the world's fourth largest exporter of coal and twelfth largest producer (Natural Resources Canada, 1994).

While coal is the only fossil fuel available in quantities that for practical purposes are inexhaustible, only one percent of the world's coal reserves are located in Canada. Yet, assuming constant extraction rates at current levels, there remain roughly 100 years of coal production from economically recoverable reserves in Canada. Table 6.1 compares coal reserves of Canada and United States. In 1993, the United States' coal stocks were about 30 times greater than Canada's, representing almost 25 percent of the world's total coal reserves.

Table 6.1
Coal Reserves in Canada and the United States, 1985-1993

	Canada			United States		
Year	Bituminous	Subbituminous and lignite	Total	Bituminous	Subbituminous and lignite	Total
	millions of tonnes					
1985	1 600	4 300	5 900	125 000	132 000	257 000
1986	3 548	3 298	6 846	131 971	131 872	263 843
1987	3 471	3 107	6 578	131 971	131 872	263 843
1988	3 433	3 075	6 508	130 787	131 359	262 146
1989	3 753	3 071	6 824	130 194	131 059	261 253
1990	3 716	3 044	6 760	129 543	130 752	260 295
1991	4 509	4 114	8 623	112 668	127 892	240 560
1992	4 509	4 114	8 623	112 668	127 892	240 560
1993	4 509	4 114	8 623	112 668	127 892	240 560

Source:
British Petroleum, various issues.

Physical accounts

In assessing Canada's endowment of coal, many aspects must be considered before the quantity of coal available for present as well as future generations can be determined. Estimates of the volume of coal present in the ground are obtained from exploration drilling, and from geological and seismological knowledge of the coal-bearing formations. Assumptions about prices, costs and technology determine whether resources can be considered as recoverable reserves and extracted profitably. The quantity of coal is determined from general criteria and more specifically, the classification of coal resources and coal reserves is based on three sets of criteria: resource feasibility, assurance of existence and technology, as shown in Figure 6.1. To qualify as a resource, coal must have potential for endowing wealth to the nation. Classifying coal from resources to reserves is a dynamic process that occurs on the basis of changing supply and demand (Smith, 1989).

The *feasibility class* distinguishes between resources of **immediate** and **future interest** (Figure 6.1). **Resources of immediate interest** are contained in coal seams that, because of favourable combination of thickness, depth, quality and location, are considered to be of immediate interest for possible exploitation. On the other hand, **resources of future interest** are contained in seams that, because of less favourable combination of thickness, depth, quality and location, may become exploitable in the foreseeable future with changes in economic factors and/or production technologies (Hughes *et al.*, 1989). Coal reserves are a subset of resources of immediate interest and are further sub-divided into those reserves in active or inactive mines.

The level of certainty with which resource quantities are known is the *assurance class* (Figure 6.1). Four categories are used to define the assurance class: **measured**, **indicated**, **inferred** and **speculative**. Measured and indicated resources have a high degree of geological certainty of existence whereas inferred resources have a relatively low degree of assurance. Speculative resources are based on few data points where coal exploration has been limited and are always classified as resources of future interest.

Although precise levels of uncertainty of these categories have not been calculated, experience with Canadian coal deposits suggests that measured resource quantities are normally known within 10 percent, indicated within 20 percent and inferred within 50 percent of estimates. Coal reserves form a portion of measured and indicated resources of immediate interest.

Coal quantities that are anticipated to be mineable based on feasibility studies, existing technology and current economic conditions are classified as **in-place** and **recoverable** resources in the *technology class.* In-place coal is that portion of coal in mineable seams with no recovery factors applied. Recoverable reserves refers to that portion of the coal in mineable seams that can be recovered with current technology and at current market prices (Hughes *et al.*, 1989).

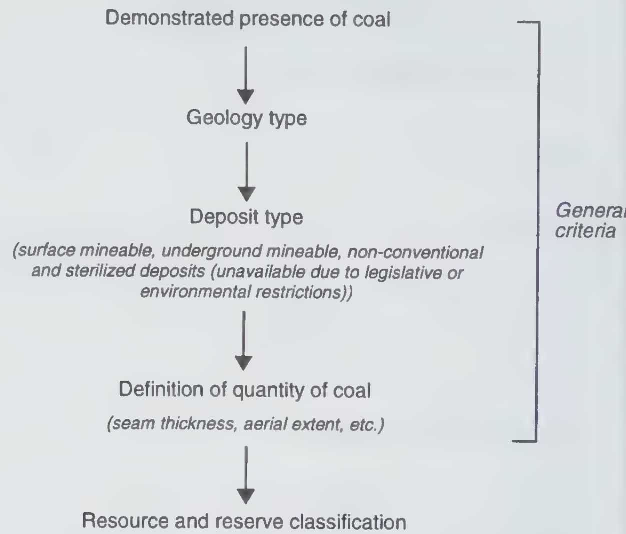
Portions of measured and indicated resources of immediate interest that are the most likely to be developed commercially are called **reserves**. Only those reserves that are recoverable in active mines are valued in the monetary accounts presented below since they have a high probability of being extracted in the foreseeable future.[1] Figure 6.2 shows the relationship between the total coal resource and recoverable reserves in active mines.

Quality

The quality of coal is another aspect to consider when developing physical resource accounts. The quality of Cana-

1. In Alberta, the reserve terminology differs. Coal reserves are called in-mine established reserves and are approximately the same as recoverable reserves in active mines. A detailed description of Alberta's terminology is presented in the following section "Provincial data".

Figure 6.1
Coal Resource and Reserve Classification

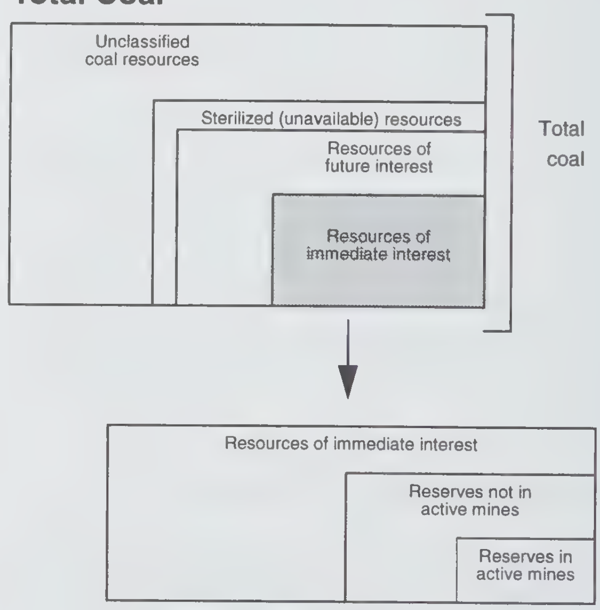


	Coal resources		Coal reserves	
Feasibility class	Immediate interest	Future interest	Active mines	Not in active mines
Assurance class	Measured, indicated inferred, speculative		Measured and indicated (or established)	
Technology class	In-place		In-place, recoverable	

Resource/ reserve criteria

Source*:*
Hughes, J.D. *et al.*, 1989.

Figure 6.2
Relationship of Resources and Reserves to Total Coal



Source:
Hughes, J.D. *et al.*, 1989.

dian coal ranges from lower quality coal called lignite and subbituminous coal to higher quality bituminous and anthracitic coal. Table 6.2 shows the different types of coal and their uses. Although all classes of coal are present in Canada, anthracite is not being currently exploited.

As the quality of the coal increases, so does its energy content. Lignite and subbituminous coal are not economic to transport because of their low energy values and corresponding lower prices. These types of coal are used for thermal power generation close to the minesite. Lignite has half the heating value of bituminous coal which means that 5 billion tonnes of bituminous coal from Nova Scotia, for example, would have the heating value equivalent to 10 billion tonnes of lignite from Saskatchewan. Furthermore, lignite commands a much lower price than bituminous coal and to follow the above example, its extraction and transport methods must be low cost for a deposit to be considered economically recoverable.[1]

Table 6.2
Coal Quality and Use in Canada

Coal class	Potential use	Location	Percentage of total Canadian production in 1992
Anthracite	Thermal coal, source of carbon for chemical production.	Nova Scotia	No production in Canada
Bituminous coal	Metallurgical and thermal coal	British Columbia	26 percent
		Alberta	16 percent
		Nova Scotia	7 percent
		New Brunswick	1 percent
Subbituminous coal	Thermal coal	Alberta	35 percent
Lignite	Minesite thermal coal	Saskatchewan	15 percent

About 70 percent of bituminous coal mined in Canada is used as metallurgical coal. Metallurgical coal is used in the production of coke which is a reducing agent and heat source for the steel industry. The remaining 30 percent of bituminous coal is used as thermal coal to generate electricity mainly in Nova Scotia and New Brunswick.

Another important characteristic of coal is its sulphur content. Increasing concerns over sulphur dioxide (SO_2) emissions and acid rain have placed a premium value on western Canadian coal reserves which have less than one percent sulphur content. Atlantic coals generally contain about four percent sulphur.

To depict more accurately Canada's reserves, the physical accounts of coal reserves are presented by type of coal. Included in the bituminous class are all the sub-classes of high, medium and low volatile bituminous coal, while subbituminous coal and lignite are reported separately.

1. In 1992, the average value of lignite was $10/tonne in Saskatchewan compared with $60/tonne for bituminous coal in Nova Scotia.

Provincial data

Energy, Mines and Resources (EMR, now known as Natural Resources Canada) evaluated coal reserves in 1976, 1977, 1982 and 1985. Table 6.3 presents a sample of the data from 1985 by province for recoverable reserves and coal resources of immediate interest.

With the exception of Alberta[2], provincial physical accounts are based on the recoverable reserve data published by EMR. Reassessments of the reserve stock were not available every year for each province, so estimates for missing years were calculated by reducing the previous years' stocks by recorded depletion. In order to obtain a more accurate estimate, one would have to take into account any evaluations of mining properties. The EMR estimates were chosen as the benchmarks since they form a consistent and complete data set.

Table 6.3
Remaining Recoverable Reserves and Resources of Coal in Canada, 1985

Province	Class of coal	Coal resources of immediate interest	Remaining recoverable reserves
		millions of tonnes	
British Columbia	Lignite	1 090	566
	Bituminous - thermal	1 610	433
	Bituminous - metallurgical	17 105	1 563
Alberta	Subbituminous coal	33 475	871
	Bituminous - thermal	815	800
	Bituminous - metallurgical	12 645	240
Saskatchewan	Lignite	7 595	1 670
New Brunswick	Bituminous - thermal	75	21
Nova Scotia	Bituminous - thermal	1405	300
	Bituminous - metallurgical	..	115
Yukon and N.W.T.	Lignite and subbituminous	2 290	..
	Bituminous - thermal	90	..
	Bituminous - metallurgical	500	..
Canada	Lignite	44 630	2 236
	Subbituminous		871
	Bituminous - thermal	2 515	1 553
	Bituminous - metallurgical	31 730	1 918
	Total	**78 875**	**6 578**
Canada	Metallurgical	31 730	4 660
	Thermal	47 145	1 918

Source:
National Energy Board, 1991.

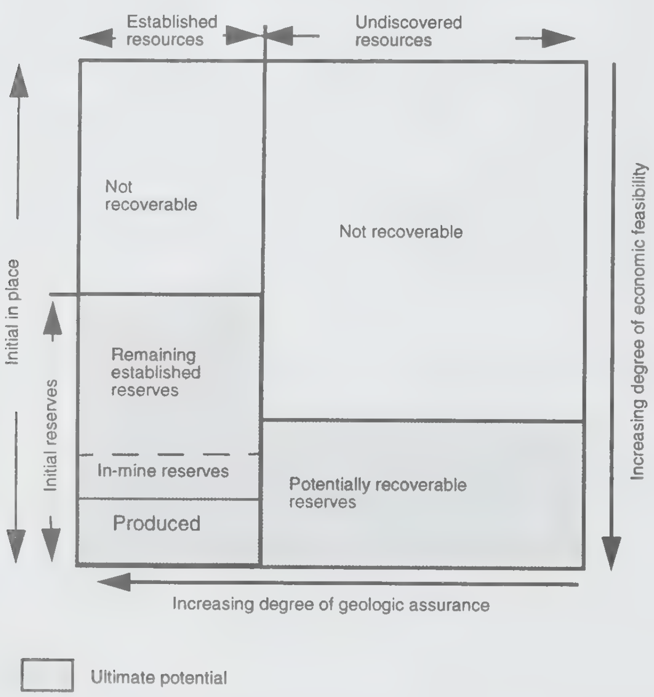
2. Data for Alberta are taken from the Alberta Energy Resources Conservation Board.

Gross mine output from Statistics Canada, published in ***Coal Mines***, Cat. No. 26-206, was used for the quantity of depletion in the physical accounts. The reserve addition column corrects for any discrepancies between opening and closing stocks that are not consistent with the simple depletion by production. Often adjustments of reserve additions can be related to opening or closing of certain coal mines or a re-evaluation of the resource/reserve base.

Alberta

Alberta has the largest share of coal reserves in Canada. The reserves are also the best documented and measured. They represent about 60 percent of Canada's total resource of immediate interest. The Alberta Energy Resources Conservation Board (ERCB) uses the term **established reserves** that is the same definition applied to oil and natural gas reserves. The quantities reported in this chapter are **remaining established reserves** defined as the reserves considered recoverable under current technology and present or anticipated future economic conditions. ERCB's terminology is applied to the McKelvey box to illustrate the relationship between the various classifications of coal resources and reserves specific to Alberta (Figure 6.3).

Figure 6.3
Alberta's Coal Resource Terminology



Source:
Alberta Energy Resources Conservation Board, 1988.

The ERCB reports remaining established reserves and distinguishes between reserves that are within mine boundary and those that are not (Figure 6.2). **In-mine reserves** represent about 8 percent of total recoverable reserves in Alberta (based on 1991 data). For the physical and monetary accounts, only in-mine established reserves are considered and this is consistent with the reserve definition used for the other provinces. Despite differences in reporting resources, EMR and ERCB do have comparable methods of calculating reserves. When comparing provincial reserve data with those of other provinces, EMR has used the in-mine established reserves calculated by ERCB for the Province of Alberta.

Alberta produces both bituminous and subbituminous coal. Physical accounts including additions and depletion were put together by combining reserves data and raw coal production from the ERCB for bituminous and subbituminous coal. The closing stock of bituminous reserves has almost tripled since 1976 (Table 6.4) and subbituminous coal reserves have increased 1.5 times since 1976 (Table 6.5). Assuming current extraction rates, the reserve life of bituminous coal is 95 years and for subbituminous coal 50 years from currently established reserves.

Alberta's coal of ultimate potential

Ultimate potential is an estimate of the initial reserves which will have become developed by the time all exploration and development of reserves has ceased. Geological prospects of the area and anticipated technological, economic and social conditions are considered when deriving the estimate. The ultimate potential includes cumulative production, remaining established reserves and presumed future reserve additions.

Although there is a large degree of uncertainty associated with estimating ultimate potential, the estimate provides a forecast of coal reserves that could be developed in the future. Table 6.6 shows the magnitude of coal reserves that could be extracted in the future.

Table 6.6
Established Reserves and Ultimate Potential in Alberta, 1991

	Remaining established reserves	Ultimate potential
	billions of tonnes	
Bituminous coal	1.4	183.6
Subbituminous coal	1.2	539.1

Source:
Alberta Energy Resources Conservation Board, 1992.

British Columbia

Unlike Alberta, British Columbia does not evaluate its reserves of coal every year. Data from EMR's reports were used to develop the physical accounts for British Columbia's reserves of bituminous coal (Table 6.4). Reserve data for the province include the quantities present in the produc-

Table 6.4
Canada's Recoverable Reserves of Bituminous Coal, 1976-1992

	Nova Scotia				New Brunswick				Alberta			
Year	Opening stock	Additions	Depletion	Closing stock	Opening stock	Additions	Depletion	Closing stock	Opening stock	Additions	Depletion	Closing stock
	thousands of tonnes											
1976	93 205	-	2 205	91 000	34 327	-	327	34 000	542 824	-	6 752	536 072
1977	91 000	387	2 387	89 000	34 000	-694	306	33 000	536 072	-	6 072	530 000
1978	89 000	-	2 921	86 079	33 000	-	348	32 652	530 000	-	7 308	522 692
1979	86 079	-	2 157	83 922	32 652	-	310	32 342	522 692	-44 929	7 763	470 000
1980	83 922	-	2 726	81 196	32 342	-	439	31 903	470 000	49 552	9 552	510 000
1981	81 196	-	2 539	78 657	31 903	-	524	31 379	510 000	-1 320	9 680	499 000
1982	78 657	369 394	3 051	445 000	31 379	-12 880	499	18 000	499 000	36 985	9 985	526 000
1983	445 000	-	2 986	442 014	18 000	-	565	17 435	526 000	330 174	10 174	846 000
1984	442 014	-	3 093	438 921	17 435	-	564	16 871	846 000	204 774	10 774	1 040 000
1985	438 921	-20 680	3 241	415 000	16 871	4 473	544	20 800	1 040 000	10 794	10 794	1 040 000
1986	415 000	-	3 275	411 725	20 800	-	480	20 320	1 040 000	380 136	10 136	1 410 000
1987	411 725	-	3 672	408 053	20 320	-	517	19 803	1 410 000	-49 722	10 278	1 350 000
1988	408 053	-	4 586	403 467	19 803	-	521	19 282	1 350 000	13 380	13 380	1 350 000
1989	403 467	-	3 147	400 320	19 282	-	495	18 787	1 350 000	4 019	14 019	1 340 000
1990	400 320	-	4 283	396 037	18 787	-	533	18 254	1 340 000	139 496	13 496	1 466 000
1991	396 037	-	4 894	391 143	18 254	-	497	17 757	1 466 000	-9 989	14 011	1 442 000
1992	391 143	-	4 502	386 641	17 757	-	354	17 403	1 442 000	-	15 069	1 426 931

	British Columbia				Canada			
Year	Opening stock	Additions	Depletion	Closing stock	Opening stock	Additions	Depletion	Closing stock
	thousands of tonnes							
1976	972 741	-	8 278	964 463	1 643 097	-	17 562	1 625 535
1977	964 463	-	9 463	955 000	1 625 535	-307	18 228	1 607 000
1978	955 000	-	9 988	945 012	1 607 000	-	20 565	1 586 435
1979	945 012	-	10 616	934 396	1 586 435	-44 929	20 846	1 520 660
1980	934 396	-	10 156	924 240	1 520 660	49 552	22 873	1 547 339
1981	924 240	-	11 781	912 459	1 547 339	-1 320	24 524	1 521 495
1982	912 459	1 197 309	11 768	2 098 000	1 521 495	1 590 808	25 303	3 087 000
1983	2 098 000	-	11 687	2 086 313	3 087 000	330 174	25 412	3 391 762
1984	2 086 313	-	20 775	2 065 538	3 391 762	204 774	35 206	3 561 330
1985	2 065 538	-34 033	35 505	1 996 000	3 561 330	-39 446	50 084	3 471 800
1986	1 996 000	-	32 360	1 963 640	3 471 800	380 136	46 251	3 805 685
1987	1 963 640	-	34 407	1 929 233	3 805 685	-49 722	48 874	3 707 089
1988	1 929 233	-	38 508	1 890 725	3 707 089	13 380	56 995	3 663 474
1989	1 890 725	-	38 152	1 852 573	3 663 474	4 019	55 813	3 611 680
1990	1 852 573	-	40 003	1 812 570	3 611 680	139 496	58 315	3 692 861
1991	1 812 570	-	39 596	1 772 974	3 692 861	-9 989	58 998	3 623 874
1992	1 772 974	-	25 987	1 746 987	3 623 874	-	45 912	3 577 962

Sources:
Energy, Mines and Resources Canada, 1976.
CANMET, 1984.
Energy, Mines and Resources Canada, 1987.
Alberta Energy Resources Conservation Board, various issues.
Statistics Canada, 1992.

ing coalfields. The large increase in reserves in 1982/1983 is attributable to the opening of 4 surface mines in the province. Since 1976, reserves of bituminous coal have increased over 80 percent while physical depletion has more than tripled.

Reserves of lignite are also located in British Columbia, however they are not being exploited. From 1976 to 1981, the quantity of recoverable reserves totalled 397 tonnes. This increased to 566 tonnes at the end of 1982 and has remained at this level to present day.

Saskatchewan

The only source of consistent data on reserves is EMR reports. The only type of coal being exploited is lignite which is located in the southern part of the province. The low quality of the coal requires extraction by surface mining methods to minimize the extraction cost. Reserves are therefore limited to that portion of the coal that lies within 45 metres of the surface and in seams exceeding 1.5 metres in thickness.

Once more the physical accounts are simply the opening stocks of reserves reduced by annual production as reported by Statistics Canada as gross mine output (Table 6.5).

Table 6.5

Canada's Recoverable Reserves of Subbituminous Coal and Lignite, 1976-1992

	Saskatchewan				Alberta				Canada			
Year	Opening stock	Gross additions	Depletion	Closing stocks	Opening stocks	Gross additions	Depletion	Closing stocks	Opening stocks	Gross additions	Depletion	Closing stocks
	thousands of tonnes											
1976	1 896 000	5 156	5 156	1 896 000	790 000	6 419	6 419	790 000	2 686 000	11 575	11 575	2 686 000
1977	1 896 000	-169 961	6 039	1 720 000	790 000	7 847	7 847	790 000	2 686 000	-162 114	13 886	2 510 000
1978	1 720 000	-	5 575	1 714 425	790 000	8 279	8 279	790 000	2 510 000	8 279	13 854	2 504 425
1979	1 714 425	-	5 013	1 709 412	790 000	9 580	9 580	790 000	2 504 425	9 580	14 593	2 499 412
1980	1 709 412	-	5 971	1 703 441	790 000	160 500	10 500	940 000	2 499 412	160 500	16 471	2 643 441
1981	1 703 441	-	6 798	1 696 643	940 000	11 500	11 500	940 000	2 643 441	11 500	18 298	2 636 643
1982	1 696 643	7 851	7 494	1 697 000	940 000	-7 000	13 000	920 000	2 636 643	851	20 494	2 617 000
1983	1 697 000	-	7 760	1 689 240	920 000	-5 500	14 500	900 000	2 617 000	-5 500	22 260	2 589 240
1984	1 689 240	-	9 917	1 679 323	900 000	-4 600	15 400	880 000	2 589 240	-4 600	25 317	2 559 323
1985	1 679 323	349	9 672	1 670 000	880 000	6 800	16 800	870 000	2 559 323	7 149	26 472	2 540 000
1986	1 670 000	-	8 280	1 661 720	870 000	7 500	17 500	860 000	2 540 000	7 500	25 780	2 521 720
1987	1 661 720	-	10 020	1 651 700	860 000	358 500	18 500	1 200 000	2 521 720	358 500	28 520	2 851 700
1988	1 651 700	-	12 148	1 639 552	1 200 000	20 000	20 000	1 200 000	2 851 700	20 000	32 148	2 839 552
1989	1 639 552	-	10 816	1 628 736	1 200 000	900	20 900	1 180 000	2 839 552	900	31 716	2 808 736
1990	1 628 736	-	9 407	1 619 329	1 180 000	41 700	21 700	1 200 000	2 808 736	41 700	31 107	2 819 329
1991	1 619 329	-	8 981	1 610 348	1 200 000	22 300	22 300	1 200 000	2 819 329	22 300	31 281	2 810 348
1992	1 610 348	-	10 027	1 600 321	1 200 000	23 020	23 020	1 200 000	2 810 348	23 020	33 047	2 800 321

Note:
Reserve data before 1979 are estimated.
Sources:
Energy, Mines and Resources Canada, 1976.
CANMET, 1984.
Energy, Mines and Resources Canada, 1987.
Alberta Energy Resources Conservation Board, various issues.
Statistics Canada, 1992.

Reserves of lignite have declined from 1 896 million tonnes in 1976 to 1 600 million tonnes in 1992 with annual depletion almost doubling over that period. At current extraction rates, there is sufficient coal for 160 years of exploitation.

Nova Scotia

The Sydney coalfield contains more than 98 percent of the reserves of bituminous coal. Coal reserves have declined since 1982 from 445 million tonnes to 387 million tonnes in 1992. There remain an estimated 85 years worth of coal production in Nova Scotia.

New Brunswick

New Brunswick can claim to have the oldest site of coal mining in North America. Exploitation of coal outcrops started as early as 1639 although no major coalfield has ever been discovered in the province's numerous seams. Coalfields are steadily being depleted as extraction is not being replaced by additions to reserves.

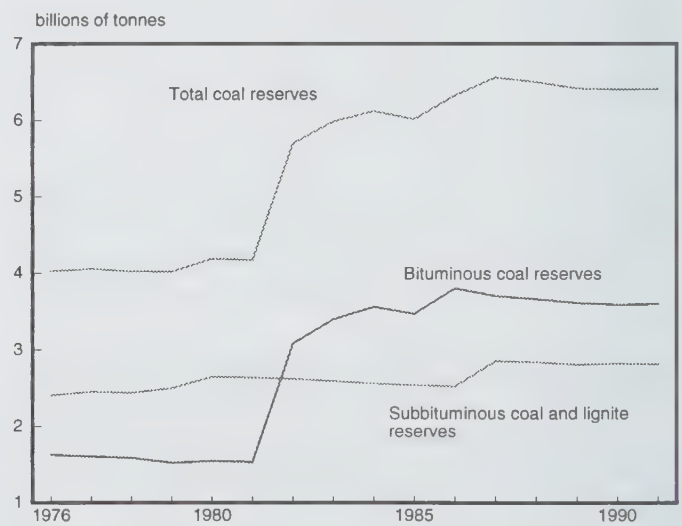
All of the high sulphur (6-8 percent) bituminous coal being mined is used as thermal coal for the province's power plants.

Canada

Reserves of bituminous coal have more than doubled since 1976 and have remained at the same level since 1985 (Figure 6.4). The level of reserves of lignite and subbituminous coal have been relatively constant since 1976 ranging from 2.6 billion tonnes to 2.9 billion tonnes. Total coal reserves in Canada reflect the same trend for bituminous coal with marked increases in coal reserves in British Columbia and Nova Scotia at the end of 1982. Generally, the stock of coal reserves as defined here is being maintained in Canada at about 6.4 billion tonnes remaining.

Figure 6.4

Remaining Recoverable Coal Reserves of Canada, 1976-1991



Remaining recoverable reserves as reported in the physical accounts above are only a small portion of the total reserve and resource base of coal. Remaining recoverable reserves of total coal represent only 8 percent of coal resources of immediate interest (Table 6.3).

Monetary accounts

Monetary valuation of natural capital is at the heart of integrated economic and environmental accounting (Bartelmus, 1994). Without such valuation, comparison of different economic and environmental activities is often exceedingly difficult. Valuation means assigning prices to what are now treated as "free goods" in the conventional national accounts.

Reserves of depletable natural resource assets "in the ground" such as coal generally do not have a market price since they are rarely bought and sold. In Canada, these assets are typically owned by government. Therefore, several methods of valuation are used to estimate or impute the market value of the reserves. Text Box 6.1 presents the algebraic description of the three methods used to value coal reserves: net price method I, net price method II and present value. A more formal description of the methodology is presented in Born (1992 and 1995).

Net price

The net price method is based on the Hotelling model which assumes that in a perfectly competitive market, the price of the marginal unit of a non-renewable resource net of extraction costs should rise over time at a rate equal to the nominal rate of interest. In other words, the price of the resource should increase at the rate of interest and there is no need for discounting. If this assumption is true, the value of the stock of the resource is equal to the net price per unit of the resource times the quantity of reserve stock.

All three methods are in fact based on the net price method. The first two variations of the net price method are presented in this paper to show the range in values of the coal stock using different assumptions about the treatment of the return to capital used to find and extract the reserves. Also, the net price is presented in order to do international comparisons of natural asset accounts. However, the net price can also be rationalized as zero time preference or a present value using a zero discount rate.

Net price method I

The first method, net price method I, imputes the value of the rent or the return to the natural capital by netting out the extraction costs and the return to invested produced capital of the coal mining industry. The return to capital is calculated as a "normal" rate of return on produced capital (using an average yield on industrial bonds) times the net capital stock of the coal industry plus the depreciation of the capital stock. A per unit rent is calculated by dividing the net rent by the quantity extracted. The resource rent per unit is then multiplied by the quantity of the remaining recoverable reserves that have been estimated in the physical accounts of coal.

In theory the net price should be net of all costs including capital costs so that it can accurately represent the value added associated with the natural resource. However, there is some uncertainty regarding the estimation of the return to the invested produced capital in the calculation of the net price, particularly when the net operating surplus is already small (United Nations, 1993). In the case of coal, in some instances, the net price becomes negative after the deduction of the return to the produced capital. This result suggests that (world market) price of the coal is so low that a

Text Box 6.1
Alternative Methods of Valuing Coal Reserves

Net price method I (based on return to capital):

$$GR = TR - C$$
$$RR = GR - (rK + \delta)$$
$$V = (RR/Q)\,S$$

Net price method II (based on the value of capital stock):

$$V = (GR/Q)S - K$$

Present value method:

$$\phi = \sum_{t=1}^{T} \frac{1/T}{(1+r)^t}$$

$$PV = \phi\,[(GR/Q)S - K]$$

TR = total revenue from extraction
C = extraction costs including fuel and electricity, material and supplies and wages
GR = gross rent
RR = resource rent
r = long-term industrial or provincial bond rate
K = net capital stock valued at replacement cost
δ = depreciation of the capital stock
V = net price value of the reserve stock
Q = quantity of the resource extracted
S = stock of remaining recoverable or established reserves
PV = present value net price
ϕ = discount factor
T = life of the reserve
t = current year

Table 6.7
Value of Coal Reserves in Canada: Net Price Method I and Method II, and Present Value, 1975-1993

	Alberta						British Columbia			Saskatchewan		
	Bituminous coal			Sub-bituminous coal			Bituminous coal			Lignite		
	Net price		Present	Net price		Present	Net price		Present	Net price		Present
Year	Method I	Method II	value	Method I	Method II	value	Method I	Method II	value	Method I	Method II	value
	millions of dollars											
1975	13 533	15 683	2 364	675	2 265	341	6 446	21 313	4 169	... [1]	3 480	130
1976	11 141	13 470	2 295	... [1]	1 580	256	3 450	24 456	3 801	70	3 589	177
1977	7 923	11 168	1 803	... [1]	1 137	221	4 137	24 700	4 320	40	2 979	190
1978	9 031	12 071	2 346	... [1]	1 695	352	4 325	25 132	4 790	... [1]	3 005	177
1979	4 732	7 834	1 814	... [1]	2 362	562	5 234	25 601	5 738	37	3 822	224
1980	5 664	9 013	2 358	288	3 222	713	... [1]	16 765	3 641	1 306	4 516	317
1981	2 792	6 533	1 719	663	4 054	978	... [1]	17 692	4 464	1 905	4 944	396
1982	6 679	10 858	2 837	677	4 981	1 365	... [1]	46 641	5 231	3 838	7 606	672
1983	14 523	22 889	3 926	570	4 914	1 504	... [1]	49 972	5 606	5 568	9 799	900
1984	11 409	25 582	3 749	1 027	5 236	1 722	... [1]	52 066	10 392	8 300	11 710	1 383
1985	4 906	19 476	2 863	1 087	5 019	1 806	... [1]	42 666	9 559	5 775	9 052	1 048
1986	6 842	26 019	2 812	282	4 004	1 470	... [1]	39 671	8 450	3 665	7 338	731
1987	5 645	23 582	2 516	1 084	5 910	1 748	... [1]	33 057	7 432	4 874	7 740	939
1988	8 832	21 392	3 026	726	5 177	1 627	... [1]	35 542	9 145	5 465	8 080	1 196
1989	9 454	20 912	3 104	1 588	5 601	1 859	... [1]	21 546	5 618	9 695	12 919	1 715
1990	11 020	23 063	3 102	2 065	6 079	2 016	... [1]	29 274	7 715	7 707	11 246	1 306
1991	15 956	25 934	3 843	2 499	5 733	2 083	... [1]	22 536	6 148	7 288	10 675	1 191
1992	16 748	25 605	3 865	2 992	5 840	2 178	... [1]	20 457	3 994	4 792	7 732	969
1993	18 354	26 277	4 023	3 301	5 836	2 222	... [1]	31 582	7 421	5 217	8 421	1 063

Notes:
Although the physical reserve data are not available for 1993, the closing stock of reserves for 1993 was calculated by subtracting the quantity extracted from 1992 closing stock.
1. The calculated value was negative, resulting from a negative resource rent. In the Canada total, these values are treated as zero.
Source:
Statistics Canada, National Accounts and Environment Division.

normal return to invested capital is not achieved (Born, 1995).

The main disadvantage of this net price method is that the assumption made regarding the rate of return to invested capital may be inappropriate. By presetting the rate of return to invested capital, no allowance is made for relatively low or high rates of return observed in the coal industry. Further, it could be argued that produced capital rather than the resource should be the residual claimant on the gross revenues.

In the case of British Columbia, negative values using net price method I have existed since 1980. Negative returns on total capital employed have been reported for 1989 to 1991 (Coopers & Lybrand, 1992). The value of coal reserves is also negative for several years for bituminous coal in Nova Scotia[1], subbituminous coal in Alberta and lignite in Saskatchewan when net price method I is used (Table 6.7).

1. The net price value of coal in Nova Scotia also includes subsidies in the total revenue of extraction. This is consistent with the definition of industry value added in national accounting calculations. Subsidies for Nova Scotia coal range from $26.7 million in 1970 to none in 1992 and the value of production ranged from $55.1 million to $203.3 million during the same time period.

Net price method II

An alternative method, net price method II calculates the resource rent by subtracting out the replacement cost of the net capital stock from the value of the reserve stock (Text Box 6.1). The advantage of this method is that it does not require an explicit assumption about the return to the produced capital associated with the coal. The values are positive when no return to capital is assumed.

Since coal is used as an input in the generation of electricity, it is assumed that the returns to capital may be captured from the returns or value added from electricity generation. The effect of this transfer pricing is assumed to have a major impact on upstream resource revenues and resource rents. By not making an explicit assumption about a "normal" return to capital, the effect of transfer pricing is reduced.

Present value

In the case of natural resource assets for which the returns are spread over a lengthy period of time, as with coal assets, a rate of discount should be used to compute the present value of the expected future returns. This flow of expected economic rents is the same as the rent calculation

Table 6.7

Value of Coal Reserves in Canada: Net Price Method I and Method II, and Present Value, 1975-1993 (Concluded)

Year	Nova Scotia			New Brunswick			Canada		
	Bituminous coal			Bituminous coal			Total		
	Net price		Present	Net price		Present	Net price		Present
	Method I	Method II	value	Method I	Method II	value	Method I	Method II	value
	millions of dollars								
1975	768	1 287	428	180	220	52	21 602	44 249	7 485
1976	607	1 070	419	113	180	31	15 381	44 344	6 980
1977	1 181	1 631	687	45	123	21	13 326	41 738	7 241
1978	666	1 044	511	285	360	69	14 308	43 306	8 245
1979	1 080	1 626	711	343	428	81	11 425	41 673	9 131
1980	900	1 362	701	467	531	142	8 626	35 408	7 871
1981	197	804	405	506	563	178	6 063	34 592	8 139
1982	754	5 347	733	320	358	164	12 268	75 790	11 002
1983	1 815	7 081	1 001	383	419	210	22 859	95 074	13 147
1984	5 607	12 041	1 695	340	379	194	26 684	107 014	19 135
1985	4 336	12 408	1 679	474	530	238	16 578	89 153	17 194
1986	... [1]	9 334	1 338	469	539	224	11 259	86 905	15 026
1987	3 042	14 104	2 023	457	520	234	15 103	84 914	14 892
1988	... [1]	7 491	1 311	493	558	258	15 517	78 239	16 563
1989	... [1]	7 516	1 314	521	592	271	21 258	69 086	13 881
1990	3 540	13 498	2 320	493	576	278	24 824	83 737	16 738
1991	2 587	10 965	2 297	544	692	320	28 875	76 536	15 881
1992	... [1]	7 355	1 681	222	462	187	24 753	67 450	12 874
1993	... [1]	8 213	1 555	349	594	239	27 221	80 923	16 523

Notes:

Although the physical reserve data are not available for 1993, the closing stock of reserves for 1993 was calculated by subtracting the quantity extracted from 1992 closing stock.

1. The calculated value was negative, resulting from a negative resource rent. In the Canada total, these values are treated as zero.

Source:

Statistics Canada, National Accounts and Environment Division.

used in the net price methods and is based on the value added of the natural resource.

As observed in calculating the net price, negative operating surpluses were obtained when a "normal return to capital" was assumed. However, since coal is an input into thermal power plants, returns to capital from upstream operations (i.e. coal extraction) may be captured from returns from electrical power generation. With low coal prices, a "normal return" to capital is not achieved under the assumptions used in net price method I. Since net price method I produced negative values in some years, the present value calculation is based on the second net price method in order to yield positive results throughout the time series.

The choice of an appropriate discount rate should reflect certain aspects of the resource being valued. There are several things to consider: a private versus a social discount rate, time preference, intergenerational equity and ownership of the resource.

The present value is calculated by using a discount rate that reflects the rate of return to the owners of the coal reserves, namely the provincial governments. A rate of 5 percent was used which is roughly equally to the average real provincial government borrowing rate for the period 1975 to 1993.

A discount factor was derived using the reserve life and assuming a real discount rate of 5 percent. The present value of the stock equals the discount factor times the net price value II (Text Box 6.1; BEA, 1994).

Comparison of the estimates

The two methods of net price valuation and the present value provide a range of the value of coal reserves in Canada. The asset value of coal reserves based on the second net price method produces positive values for all types of coal in all provinces which is not the case for net price method I. The present value is simply the discounted value derived from the second net price method.

Only the stock of recoverable reserves of coal is used in estimating the value of Canada's reserves. This is consistent with the other natural resource stock accounts already developed. For Canada, the net price value ranges from $27.2 billion to $80.9 billion in 1993. The stock of coal reserves would add between 1.0 percent and 3.0 percent to Canada's national wealth of $2 630 billion.[1] Over time, the value of coal reserves as a share of an expanded estimate of wealth has decreased; in 1975, coal reserves added from 3.1 to 6.2 percent to national wealth.

1. National wealth is the sum of tangible or non-financial assets across all domestic sectors.

The present value estimates ranged from $7.5 billion in 1975 to $16.5 billion in 1993. These estimates would add 1.1 percent to national wealth in 1975 and 0.6 percent in 1993.

Conclusion

Recoverable reserves of coal as presented in the physical accounts, represent only a small portion of Canada' s total coal resource. Recoverable reserves in active mines represent approximately 8 percent of coal resources of immediate interest. Although Canada has only one percent of the world's coal reserves, there remain 78 years of bituminous coal and 85 years worth of subbituminous coal and lignite assuming current depletion rates.

Results from the physical accounts indicate that Canada's stock of coal reserves has been maintained since the 1980s. Coal will remain an important primary energy source, particularly in Nova Scotia, Ontario, Saskatchewan and Alberta. In 1993 coal-fired electric power plants generated 15 percent of electricity production, up 5 percent from the 1970s.

In order to treat coal reserves and other natural resources as part of Canada's national wealth, monetary accounts had to be developed also. For inclusion in the National Balance Sheet Accounts, the present value is preferred as an estimate of the market value. Estimates of coal values using the net price method I resulted in some negative values. Negative asset values present empirical problems with regards to balance sheet entries. However, positive values were obtained when no return to invested capital was allowed for. Further work will be needed before deciding on an appropriate valuation method.

References

Alberta Energy Resources Conservation Board, 1988,1992, various issues, ***Reserves of Coal***, ERCB ST, Calgary.

Bartelmus, Peter, 1994, ***Environment, Growth and Development, The Concepts and Strategies of Sustainability***, Routledge, London.

Born, Alice, 1992, ***Development of Natural Resource Accounts: Physical and Monetary Accounts for Crude Oil and Natural Gas Reserves in Alberta, Canada***, National Accounts and Environment Division, Discussion Paper No. 11, Statistics Canada, Ottawa.

_____, 1995, ***Valuation of Canada's Mineral Resources: A Discussion of Conceptual Issues***, National Accounts and Environment Division, Discussion Paper No. 21, Statistics Canada, Ottawa.

British Petroleum, various issues, ***BP Review of World Energy***, London.

Bureau of Economic Analysis (BEA), 1994, ***Accounting of Mineral Resources: Issues and BEA's Initial Estimates***, Survey of Current Business, Washington, D.C.

CANMET, 1984, ***Coal Mining in Canada: 1983***, CANMET Report 83-20E.

Coopers & Lybrand Consulting Group, 1991, ***Review of the British Columbia Coal Industry***.

Energy, Mines and Resources Canada, 1976, ***Assessment of Canada's Coal Resources and Reserves***, Cat. No. EP 77-5, Ottawa, Ontario.

_____, 1987, ***Coal Reserves of Canada - 1987***, Geological Survey of Canada, Ottawa.

Gravel, G., G.J. Lawrance and S. Ecclestone, 1995, ***Valuing Ontario's Timber Resource***, in this issue, Chapter five, Ottawa.

Hughes, J.D., L. Klatzel-Mudry and D.J. Nikols, 1989, ***A Standardized Coal Resource/Reserve Reporting System***, Geological Survey of Canada, Energy, Mines and Resources, Paper 88-21.

Moll, R.H.H. and G.J. Lawrance, 1995, ***Natural Resource Stock Accounts: Physical Data for Ontario's Timber***, National Accounts and Environment Division, Discussion Paper 19, Statistics Canada, Ottawa.

National Energy Board, 1991, ***Canadian Energy Supply and Demand***, Ottawa.

Natural Resources Canada, 1994, ***Statistical Review of Coal in Canada, 1993***, Mining Sector, Ottawa.

Smith, G. G., 1989, ***Coal Resources of Canada***, Geological Survey of Canada, Energy, Mines and Resources Canada, Paper 89-4, Ottawa.

Smith, Philip, 1995, ***Statistics Canada's Environmental Statistics Program***, in this issue, Chapter one, Ottawa.

Statistics Canada, 1992, ***Coal Mines***, Cat. No. 26-206, Ottawa.

7 Water Use in Economic and Domestic Activity

by Tony Johnson[1]

Introduction

Compared with much of the world, Canada is well endowed with available fresh water and has one of the world's longest coastlines. Indeed, the industrial structure of its economy and the lifestyle of its people have been heavily influenced by the abundance of water and other natural resources. It should be noted however, that 90 percent of Canada's population lives within a narrow band along its southern boundary, while 60 percent of its water supply flows north towards the Arctic Ocean (Environment Canada, 1992, p. 2). There has been ample evidence that growth in urbanisation and economic activity has stressed the ability of aquatic systems to cope with the demands placed on them.

The need for the enhancement and maintenance of Canada's water resources has been the focus of initiatives at all levels of government. The 1987 Federal Water Policy sets out a national strategy for the protection and enhancement of the quality of water resources and promotes the wise and efficient use of water. This goal has been reaffirmed in Canada's Green Plan (Government of Canada, 1990).

Statistics Canada is committed to the provision and promotion of statistical information on the environment as an important aid to informed decision making. A major facet of this work is aimed at developing satellite accounts to integrate, as far as possible, environmental and natural resource concerns with the traditional national accounting framework.

Two major accounts within this satellite system, the natural resource use accounts and the waste output accounts, are cast within an input-output industry framework[2]. They enable analysts to relate natural resource use (or waste output), measured in physical terms, to the production and consumption activities (measured in monetary terms) of industries, government and households.

This chapter reports on work in progress towards the development of resource use accounts for water. It presents data for one year (1991) at the national level only. Future work will extend the data set to cover a time series and individual provinces. There is also a longer term prospect of incorporating water-use micro data into Statistics Canada's Geographic Information System. Water-use issues are of course more effectively studied on a provincial or small area basis.

1. The author acknowledges the help provided by Debbie MacDonald in the preparation of this article.

2. Waste output accounts for greenhouse gas emissions and resource use accounts for energy have already been developed at Statistics Canada (see Canadian Carbon Dioxide Emissions, 1981-1990, included in this publication).

A framework for water use statistics

The hydrologic cycle describes the natural recirculation of the world's water supply. From its various repositories on earth (oceans, rivers, lakes, streams, groundwater, snow, ice and plants), water gravitates towards the seas, is evaporated and transpired to the atmosphere as water vapour, and is returned as precipitation. There is a strong interaction between the hydrosphere, the atmosphere and the land. For instance, the oceans and groundwater contain dissolved minerals from geological formations and water is oxygenated through contact with the atmosphere. These are natural processes. Humans, through economic processes and other activity, also profoundly affect water systems, often in ways that are deleterious to their quality. This can be directly through the withdrawal of water, the discharge of wastes, or the creation of water diversions, and, indirectly, through the transfer of land-based and airborne wastes to water systems through the hydrological cycle.

Water use accounts

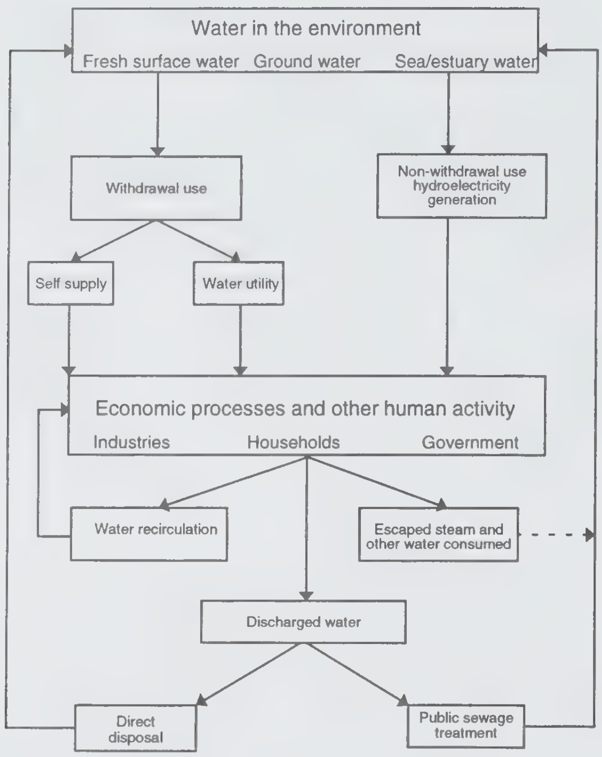
Water use accounts can only hope to shed light on a small (albeit important) component of these interactions. Figure 7.1 is a schematic representation of water use in economic and other human activity. Broadly, two major uses of water are defined: withdrawal use, and non-withdrawal ("in-stream") use.

Withdrawal use involves the diversion of water from source and its transport to the place of use. Its return to source may be delayed or it may not be returned at all, thereby impacting on water flow available "downstream" for the maintenance of natural ecosystems and other competing uses. The use of withdrawn water in industrial processes (for example for mixing and transporting raw materials, cleaning, cooling and heating) and for human sanitation almost always involves a systematic degradation of its quality, notwithstanding pollution abatement practices.

Non-withdrawal use includes sea and river transport, hydro electricity generation, fish culture, and water and snow sports. Except for hydro electricity generation, non-withdrawal use does not diminish supply and water quality degradation tends to be incidental, although it can be no less devastating for the environment (for example, crude oil spills and transfers of exotic aquatic species in ballast water).

Although water use in hydroelectricity generation is essentially a non-withdrawal use (because the activity occurs "in-stream"), it also has elements which are more characteristic of withdrawal use. Dams and diversions modify stream flow for year round electricity generation. Furthermore, dams involve the flooding of terrestrial ecosystems upstream, with resultant changes in water quality that are not incidental (for example, increased oxygen demands of decomposing organic matter). Because of its hybrid nature, and its prominence as a major water-use issue in Canada, it warrants separate identification in Figure 7.1.

Figure 7.1
Water Use in Economic and Other Human Activity



Note:
The flows shown for non-withdrawal use represent flows of services, not water, from the environment. The dashed arrow signifes that a substantial portion may be lost to the local environment, but not to the environment at large.

Although the non-withdrawal use of water contributes enormously to economic and other human activity, the water use account presented here is defined to include only the withdrawal use of water. The interaction between the environment and the former category is perhaps best measured using a variety of indicators such as accidental spills data and the area of resevoirs associated with hydroelectricity generation.

The water use account focuses on the following:

- the users of water (industries, households and government);
- the source of supply (fresh surface water, ground water and sea/estuary water), and whether it is drawn directly by the user (self-supplied) or supplied by a municipal water utility;
- the use to which the water is put (for example domestic use, cooling, industrial processes, sanitation);
- the incidence of water recirculation;
- water "consumption";[1] and,
- the quantity and quality of waste water discharged by each sector into the environment.

This is not a complete list of water-use variables that could be of interest for analysis. For example, studies of price elasticities of demand for water require information on the cost of obtaining and discharging water. However, the water-use variables listed above capture the important water resource interactions with economic and household activity. The factors driving this interaction are subjects for separate analysis (see for example Tate, Renzetti and Shaw, 1992).

Input-output analysis

The Canadian System of National Accounts (CSNA) provides an integrated and comprehensive picture of economic activity, both within Canada and between Canada and the rest of the world. Gross Domestic Product (GDP), the overall measure of production in the economy, is probably the most widely used and publicised summary aggregate from the CSNA. The input-output tables present the most detailed elaboration of GDP, focusing in particular on the production and intermediate consumption activity of industries and the distribution of goods and services to final consumers. Because of this focus on industry use and production of commodities, input-output tables (suitably augmented) can provide a useful framework in which to study the interaction between the environment (including natural resource use) and economic activity.[2]

The national accounts are of course key to macroeconomic analysis and policy advising. Input-output analysis is an established technique for use in macroeconomic forecasting and simulation models. Therefore, the presentation of natural resource use (and waste) data according to the concepts and classifications used in the input-output framework provides economic analysts with a convenient data set to for-

1. Includes water lost as steam or evaporated in cooling and heating processes, irrigation water lost by evaporation and transpiration, water embodied in products (for example beverages), and reticulation system leakages. In concept, it is a measure of the quantity of water not returned to point of source.
2. The potential for using input-output analysis for the study of environmental issues has been recognised for many years. Victor (1972), provided a generalised framework for the incorporation of environmental commodities into the Canadian input-output tables. This work forms much of the conceptual basis for the input-output studies currently underway at Statistics Canada.

mally integrate environmental commodities into economic model building generally.

A detailed technical description of input-output tables and their augmentation for the study of environmental commodities (greenhouse gas emissions) has already been published by Statistics Canada in a discussion paper (Smith, 1991). As the techniques presented in that paper can be readily generalised to other environmental commodities, including water use, only a brief non-technical description of input-output analysis is presented here to aid the readers interpretation of the data presented in Tables 7.2 and 7.4.

A basic identity in both economic theory and national accounting is that the supply of commodities (defined broadly to include services), equals demand. Commodities produced by an industry are either purchased by another industry for input to its production (intermediate consumption) or sold to final consumers (final consumption). Input-output tables are a fully balanced series of matrices showing commodity flows between industries and to final consumers. They are compiled at a very detailed level (627 commodities, 216 industries and 136 categories of final demand), but are published at a more aggregated level mainly for reasons of confidentiality under the provisions of the *Statistics Act.*

Three basic input-output tables are compiled for each year: the make matrix, showing the value of each commodity produced by each industry; the use matrix, showing the requirement of each industry for commodity and primary inputs; and the final demand matrix, showing the value of each commodity supplied to final demand. These tables are, of course, in value (dollar) terms. In the augmented input-output model employed in this study, an additional table relating to water use by each industry is also included (but measured in physical terms).

Using the information contained in each of these tables, and given the identity that the supply of commodities equals demand, quite powerful input-output models can be formulated. For example, the water requirements of industries given various economic growth scenarios can be simulated and forecast (see for example Tate, 1985). Input-output derivations are shown in Tables 7.2 and 7.4.

Sources of estimates and data quality

Estimates of water use for the major water-using industries contained in Tables 7.1 and 7.3 are derived from Environment Canada surveys. However estimates for the relatively small water using industries (the majority of industries), have been prepared by Statistics Canada from various sources in order to approximate all-of-Canada coverage, and to provide estimates for all industries and final demand sectors enumerated in the input-output tables (although they are published at a more aggregated level here). Important comments about data quality are contained in the following paragraphs.

Environment Canada, in co-operation with Statistics Canada and the provinces, has been collecting water-use data from industries and municipalities for many years. Industrial Water Use Surveys were conducted for 1972, 1976, 1981, 1986 and 1991[1], while municipal surveys were conducted for 1983, 1986, 1989 and 1991. Agriculture water-use estimates are prepared by Environment Canada using data for livestock numbers and land-area under irrigation together with water-use coefficients.

Industrial Water Use Survey

The Industrial Water Use Survey collects water use data for the mining, manufacturing and thermal electric power systems industries. In order to keep collection costs to acceptable levels, only business establishments classified by Statistics Canada as "large businesses" are surveyed. Also, manufacturing industries that are considered relatively small water users are not surveyed except where their industrial processes are known to result in high emissions of pollutants, despite their low water use. The 48 manufacturing industries surveyed (out of 100 manufacturing industries in the more detailed input-output industry classification) are expected to account for approximately 95 percent of water use by manufacturers.

Because of the predominance of low-cost self-supply in major water-using industries, and because municipal authorities often charge without (or with only partial) metering, some businesses may not keep accurate, if any, records of the volume of water used. Therefore, there is often a degree of approximation in survey responses and the incidence of non-response is fairly high, necessitating imputations. Despite these shortcomings, it is believed that the Industrial Water Use Survey provides data of acceptable quality.

Special mention should be made of some factors affecting the accuracy of estimates for the mining industries. The quarries and sand pits industry (6) and the services related to mineral extraction industry (7) are not surveyed for water use. Estimates contained in Table 7.1 are approximations developed at Statistics Canada from other sources. Also, for the 1991 water use survey, coverage of the oil and natural gas industry was not sufficient to produce reliable estimates. The estimates contained in Table 7.1 for this industry are based on 1986 water-use data adjusted for the changed level of oil and natural gas production in 1991. However, because of uncertainties in accounting for major shifts in mining technology, the estimates should be regarded as indicative only.

The existence of minewater in water discharge data introduces some problems of interpretation. Although minewater is used as a source of water in mining operations, substantial amounts are simply pumped from the mine in order to prevent flooding. Conceptually, in these estimates all mine-

1. A full description of the survey methodology, data items collected and a summary of results is contained in Tate and Scharf (1995, pending) and in earlier issues by the same authors.

water discharged is regarded as water use although it may not be used directly in mining processes. This is because it involves diversion of groundwater and the discharge of effluents. For the mining industry, water intake is set to equal water discharged (the mine water component of water discharge is not known), with the consequence that water consumed is artificially shown as zero.[1]

Municipal data and sector and industry allocations

Municipal surveys[2] collect information on water supplied by public water utilities from all municipalities with a population of 1 000 or more. They are asked to classify water supplied to four user classes: "residential", "industrial", "commercial" and "other". No further industry detail is available from the survey.

Water included in "other" was a substantial 15 percent of total municipal water supplied in 1991, and reflects a number of factors including the incidence of respondents who could not provide or estimate adequate customer data for water volume because water metering is not used (or is only partially used). It also includes system leakages and some public uses such as for street cleaning and fire fighting. As the estimates in this paper are presented by sector and industry, water included in "other" had to be reallocated. For municipalities that included all water supplied in that category, those amounts were reallocated according to provincial averages for the four user classes. As the remainder was in the order of engineering estimates of system leakages, it was included in the government sector in Table 7.1. This approach attributes the leakage to water use by the municipal water utility (as owner of the supply infrastructure) rather than the customer.

Municipal water classified as "domestic" formed the basis of the personal sector estimates contained in Table 7.1. However, domestic water use by over six million Canadians is not captured in the survey because they either reside outside the municipalities in the survey or they do not draw water from a municipal water utility. The figures shown in Table 7.1 include an estimate for this missing domestic water use, based on water use per person in the surveyed sector adjusted for the affect of lifestyle differences, based on U.S. studies (U.S. Geological Survey, 1987, p. 71).

A variety of sources were used to allocate the "industrial" and "commercial" user classes to industry. As the Industrial Water Use Survey asks respondents to supply information on their source of water, municipal supply for those respondents can be taken from that source. Estimation techniques were used to allocate the remainder of municipal supply to individual industries and the government sector.

1. In practice, water consumption is calculated by subtracting water discharged from water intake.
2. Environment Canada, Municipal Water Use Data (MUD).

The approach used in deriving the estimates was first to take employment data for the government sector and the remaining industries and combine with other person-based indicators including school enrollment, hospital and care-facility bed days, persons in correctional institutions, passengers through airports, and overnight stays in hotels. This result was multiplied by a water-use coefficient (water use per person). Differences between the aggregate all-industry first estimate derived in this way and the benchmark provided an indication of the suitability of assumptions. Any differences after further adjustments were allocated on a *pro rata* basis.

Where available, water-use coefficients for estimated manufacturing and mining industries were based on comparable U.S. data (U.S. Bureau of the Census, 1982).[3] Coefficients for the remaining industries and the government sector were chosen individually after considering a variety of indicators. These included a micro-data analysis of water use per employed person by industries included in the Industrial Water Use Survey, an analysis of water audit studies undertaken by Public Works Canada for a variety of government buildings, and domestic water use per person.

As the methods are indirect, the resulting estimates should be regarded more as "approximations" or "allowances" for the purpose of input-output analysis of aggregate water use, and are not regarded as reliable in their own right. Nevertheless, it was considered important that estimates be made for these industries, as analysis of municipal water demand is an important area of economic and environmental study, particularly as the provision and maintenance of water utility and sewage treatment infrastructure is a large public cost. Table 7.1 contains a column signifying whether estimates are derived substantially from 1991 survey data or from the various indirect sources.

Because of lack of data, it is assumed that these relatively small water using industries and the government sector draw water only from municipal supplies, (water withdrawals from other sources are shown as zero in Tables 7.1 and 7.2). There will be cases where this assumption does not hold. For example, accommodation and recreation facilities such as golf courses that are close to rivers and lakes typically supply their own water.

Analysis of water use estimates

Canadian industries, households and governments withdrew 45 billion cubic metres of water from the environment in 1991, approximately 90 percent of which was returned at

3. Water use in U.S. mining and manufacturing establishments for 1983 was collected as a follow up to the 1982 U.S. Census of Mining and Manufacturing and is the latest year for which detailed industry data are available. Use of these data to provide water use per employed person co-efficients for the derivation of estimates in this paper rests on the assumption that manufacturing technology in respect of water use and capital intensity has not changed in almost a decade and that U.S. results are transferrable to Canada.

Table 7.1

Water Use by Sector, 1991

	Self supplied Surface	Self supplied Ground[1]	Self supplied Sea/estuary	Municipal	Total intake	Water recirculated	Gross water use	Water consumed	Water discharged	Data reliability[2]
	millions of cubic metres									
Business sector										
1 Agricultural and related services	3 472.0	519.0	-	--	3 991.0	-	3 991.0	3 089.0	902.0	E
2 Fishing and trapping	-	-	-	-	-	-	-	-	-	E
3 Logging and forestry	-	-	-	-	-	-	-	-	-	E
4 Mining	280.9	181.7	5.7	20.2	488.5	1 220.7	1 709.2	-	488.5	S
5 Crude petroleum and natural gas	102.1	6.0	-	0.3	108.4	735.6	844.0	56.0	52.4	E
6 Quarries and sand pits	65.0	-	-	-	65.0	-	65.0	13.0	52.0	E
7 Services related to mineral extraction	5.0	-	-	-	5.0	-	5.0	2.5	2.5	E
Sub-total, primary resource industries (1-7)	**3 925.0**	**706.7**	**5.7**	**20.5**	**4 657.9**	**1 956.3**	**6 614.2**	**3 160.5**	**1 497.4**	
8 Food products	72.9	45.1	65.1	179.5	362.6	201.1	563.8	29.6	333.0	S
9 Beverages	18.8	12.2	-	44.3	75.3	16.7	92.0	12.2	63.1	S
10 Tobacco products	-	-	-	1.8	1.8	1.8	3.6	0.4	1.4	E
11 Rubber products	4.7	8.7	-	8.5	21.9	56.3	78.1	2.1	19.8	S
12 Plastic products	2.4	0.9	-	53.9	57.2	261.0	318.2	3.7	53.5	S
13 Leather and allied products	-	-	-	2.3	2.3	0.2	2.5	0.1	2.2	E
14 Primary textile and textile products	249.3	1.1	-	29.4	279.9	192.3	472.2	36.6	243.3	S
15 Clothing	-	-	-	9.3	9.3	0.9	10.3	0.5	8.9	E
16 Wood products	39.8	2.3	7.3	24.2	73.7	6.1	79.8	15.9	57.7	S
17 Furniture and fixtures	-	-	-	5.9	5.9	0.6	6.5	0.3	5.6	E
18 Paper and allied products	2 718.0	31.1	2.9	154.3	2 906.2	2 242.6	5 148.8	184.8	2 721.4	S
19 Printing, publishing and allied products	-	-	-	13.4	13.4	1.3	14.7	1.2	12.1	E
20 Primary metal products	1 487.9	1.6	4.2	89.5	1 583.1	1 715.3	3 298.4	91.6	1 491.5	S
21 Fabricated metal products	7.2	0.9	-	50.9	59.0	32.7	91.7	3.4	55.6	E
22 Machinery	-	-	-	23.1	23.1	2.3	25.4	4.1	19.0	E
23 Transportation equipment	3.6	0.4	--	107.8	111.8	39.0	150.8	9.1	102.7	E
24 Electrical and electronic products	-	-	-	28.2	28.2	2.8	31.0	2.9	25.3	E
25 Non-metallic mineral products	43.4	32.5	0.3	74.4	150.5	172.8	323.3	52.8	97.8	S
26 Refined petroleum and coal products	323.8	1.6	93.1	21.0	439.4	1 018.1	1 457.5	34.6	404.8	S
27 Chemical and chemical products	1 223.4	2.1	0.6	72.2	1 298.3	1 006.3	2 304.6	95.2	1 203.1	S
28 Other manufacturing industries	-	-	-	7.3	7.3	0.7	8.0	0.4	6.9	E
Sub-total, manufacturing industries (8-28)	**6 195.1**	**140.3**	**173.5**	**1 001.3**	**7 510.3**	**6 971.0**	**14 481.3**	**581.7**	**6 928.6**	
29 Construction	0.3	-	-	3.5	3.9	-	3.9	3.9	-	E
30 Transportation	-	-	-	8.5	8.5	-	8.5	2.0	6.5	E
31 Pipeline transport	-	-	-	0.1	0.1	-	0.1	0.1	-	E
32 Storage and warehousing	-	-	-	0.5	0.5	-	0.5	0.1	0.4	E
33 Communications	-	-	-	5.1	5.1	-	5.1	0.5	4.6	E
34 Thermal electric power and other utilities	26 124.8	8.8	2 148.4	6.7	28 288.7	3 374.3	31 663.0	105.2	28 183.6	S
35 Wholesale trade	-	-	-	15.8	15.8	-	15.8	1.6	14.2	E
36 Retail trade	-	-	-	37.4	37.4	-	37.4	11.2	26.2	E
37 Finance and real estate	-	-	-	15.1	15.1	-	15.1	1.5	13.6	E
38 Insurance	-	-	-	2.2	2.2	-	2.2	0.2	2.0	E
41 Business services	-	-	-	17.6	17.6	-	17.6	1.8	15.8	E
42 Educational services[3]	-	-	-	0.9	0.9	-	0.9	0.1	0.8	E
43 Health services[3]	-	-	-	32.0	32.0	-	32.0	3.2	28.8	E
44 Accommodation and food services	-	-	-	135.4	135.4	-	135.4	27.1	108.3	E
45 Amusement and recreational services	-	-	-	46.1	46.1	-	46.1	9.2	36.9	E
46 Personal and household service	-	-	-	42.5	42.5	-	42.5	4.3	38.3	E
47 Other services	-	-	-	7.9	7.9	-	7.9	0.8	7.1	E
Sub-total, service industries (30-33,35-47)	-	-	-	**367.1**	**367.1**	-	**367.1**	**63.6**	**303.5**	
Sub-total, business sector (1-47)	**36 245.3**	**855.8**	**2 327.6**	**1 399.2**	**40 827.9**	**12 301.6**	**53 129.5**	**3 914.8**	**36 913.1**	
Personal sector	..	..	..	**2 777.0**	**3 334.0**	-	**3 334.0**	..	..	S
Government sector[4]	-	-	-	**949.0**	**949.0**	-	**949.0**	..	..	E
Sub-total, personal and government sectors	..	..	..	**3 726.0**	**4 283.0**	..	**4 283.0**	..	..	
Total, whole economy	..	..	..	**5 125.2**	**45 110.9**	**12 301.6**	**57 412.5**	..	..	

Notes:

1. Includes mine water discharged.
2. "S" denotes an estimate which is predominantly based on survey data available for 1991. "E" denotes an estimate which is predominantly based on indirect methods or survey sources that are significantly out of date. These latter estimates should be interpreted as "approximations".
3. Includes services provided by private sector only. Public education and health are included in estimate for the government sector.
4. Includes 598 million cubic metres of water unaccounted for or lost as leakage in municipal water systems.

Source:

Statistics Canada, National Accounts and Environment Division.

Table 7.2

Derived Water Use Statistics for Industries, 1991

		Self supplied	Municipal	Total intake	Gross use	Water consumed	Water discharged	Use rate[1]	Consumption rate[2]
		thousands of cubic metres per million dollars of output							
1	Agricultural and related services	167.5	-	167.5	167.5	129.6	37.9	1.0	77.4
2	Fishing and trapping	-	-	-	-	-	-	-	-
3	Logging and forestry	-	-	-	-	-	-	-	-
4	Mining	38.7	1.7	40.4	141.2	-	40.4	3.5	-
5	Crude petroleum and natural gas	5.8	--	5.8	45.1	3.0	2.8	7.8	51.7
6	Quarries and sand pits	59.1	-	59.1	59.1	11.8	47.3	1.0	20.0
7	Services related to mineral extraction	1.2	-	1.2	1.2	0.6	0.6	1.0	50.0
8	Food products	4.6	4.5	9.1	14.1	0.7	8.3	1.6	8.2
9	Beverages	5.2	7.4	12.7	15.5	2.0	10.6	1.2	16.1
10	Tobacco products	-	0.9	0.9	1.9	0.2	0.7	2.0	24.5
11	Rubber products	5.0	3.1	8.1	28.9	0.8	7.3	3.6	9.7
12	Plastic products	0.6	9.4	9.9	55.3	0.6	9.3	5.6	6.4
13	Leather and allied products	-	2.4	2.4	2.6	0.1	2.3	1.1	5.8
14	Primary textile and textile products	43.4	5.1	48.5	81.8	6.3	42.1	1.7	13.1
15	Clothing	-	1.5	1.5	1.6	0.1	1.4	1.1	5.0
16	Wood products	3.7	1.8	5.5	6.0	1.2	4.3	1.1	21.6
17	Furniture and fixtures	-	1.5	1.5	1.6	0.1	1.4	1.1	5.0
18	Paper and allied products	128.0	7.2	135.2	239.5	8.6	126.6	1.8	6.4
19	Printing, publishing and allied products	-	1.0	1.0	1.1	0.1	0.9	1.1	9.4
20	Primary metal products	69.3	4.2	73.5	153.0	4.3	69.2	2.1	5.8
21	Fabricated metal products	0.5	3.2	3.7	5.7	0.2	3.5	1.6	5.7
22	Machinery	-	2.5	2.5	2.8	0.5	2.1	1.1	17.8
23	Transportation equipment	0.1	2.1	2.2	3.0	0.2	2.0	1.3	8.1
24	Electrical and electronic products	-	1.4	1.4	1.5	0.1	1.2	1.1	10.4
25	Non-metallic mineral products	11.7	11.5	23.2	49.8	8.1	15.1	2.1	35.0
26	Refined petroleum and coal products	23.9	1.2	25.1	83.2	2.0	23.1	3.3	7.9
27	Chemical and chemical products	54.7	3.2	57.9	102.7	4.2	53.6	1.8	7.3
28	Other manufacturing industries	-	1.1	1.1	1.2	0.1	1.1	1.1	5.9
29	Construction	--	--	--	--	--	-	1.0	100.0
30	Transportation[3]	-	0.2	0.2	0.2	--	0.2	1.0	23.4
31	Pipeline transport	-	--	--	--	--	-	1.0	100.0
32	Storage and warehousing	-	0.4	0.4	0.4	0.1	0.3	1.0	20.0
33	Communications	-	0.2	0.2	0.2	--	0.2	1.0	10.0
34	Electric power	1 056.9	0.2	1 057.1	1 183.2	3.9	1 053.2	1.1	0.4
35	Wholesale trade[3]	-	0.3	0.3	0.3	--	0.3	1.0	10.0
36	Retail trade[3]	-	.0.7	0.7	0.7	0.2	0.5	1.0	30.0
37	Finance and real estate	-	0.2	0.2	0.2	--	0.2	1.0	10.0
38	Insurance	-	0.2	0.2	0.2	--	0.2	1.0	10.0
41	Business services	-	0.4	0.4	0.4	--	0.4	1.0	10.0
42	Educational services	-	0.4	0.4	0.4	--	0.4	1.0	10.0
43	Health services	-	1.7	1.7	1.7	0.2	1.6	1.0	10.0
44	Accommodation and food services	-	5.1	5.1	5.1	1.0	4.1	1.0	20.0
45	Amusement and recreational services	-	4.7	4.7	4.7	0.9	3.8	1.0	20.0
46	Personal and household service	-	4.9	4.9	4.9	0.5	4.4	1.0	10.0
47	Other services	-	0.6	0.6	0.6	0.1	0.6	1.0	10.0

Notes:
1. Calculated as gross use divided by total intake.
2. Calculated as water consumed divided by total intake times 100.
3. Output for the transport, retail and wholesale trade industries is defined as the margin after deducting the value of commodity inputs from the transaction value of output.

Source:
Statistics Canada, National Accounts and Environment Division.

or close to point of source after use. Total intake represented 1.5 percent of estimated precipitation for the year (2 905 cubic kilometres). Precipitation measures the amount of water renewed annually through the hydrological cycle.

The agriculture, manufacturing and thermal electric power industries together accounted for 88 percent of total water withdrawals in 1991, with domestic use accounting for only 7 percent. Thermal electric power was by far the largest user, accounting for 63 percent. Because of its large contribution to water use totals, it is often useful to isolate data for thermal power when analysing water use. Three of the 21 manufacturing industries represented in Table 7.1 (paper and allied products (18), primary metals (20) and chemical and chemical products (21)) accounted for 77 percent of manufacturing water use.

When viewed in terms of direct water-use coefficients (water withdrawals per dollar unit of output) in Table 7.2, the above mentioned industries also ranked high among all industries, with the electric power industry using more water per unit of output than any of the others, again by a large factor.

Comparisons of the magnitude of water withdrawals in isolation can be misleading, as ultimately the environmental impact of water use is a consequence of the discharge of water-borne pollutants and water consumption or diversion. Therefore, the use to which water is put in economic and human processes and the pollution abatement practices in-place within an establishment are also important elements to consider. Only limited information on these aspects of water use is available from the water use survey (see below).[1]

Only 11 percent of water was drawn from municipal sources in 1991, the remainder being self supplied. However, if the thermal electric power industry is excluded, the municipal proportion was a more substantial 30 percent. Of course, municipal water is also drawn from (and returned to) the environment. If municipal and rural water was withdrawn from source in the same proportions as in 1981 (Statistics Canada, 1994, p. 279), 91 percent of all water withdrawals in Canada would have been taken from fresh surface waters, 4 percent from ground water and 5 percent from sea/estuary sources.

Agriculture was by far the largest consumptive user of water, accounting for 79 percent of water consumed by industries. Water consumption refers to water that is not returned (discharged) at or close to point of source after use. Of water used for irrigation and livestock watering, 23 percent is estimated to be discharged back to source. The concept of discharge for the agriculture industry is defined to include waste irrigation water that drains through the soil to the water table, thereby returning more or less to nearby surface waters. Consumption rates for each industry are shown in Table 7.2. Estimates are not available for household and government water consumption.

Gross water use measures an industry's technical requirement for water in production processes (given current technology and water cost and supply conditions).This requirement for water can be met using withdrawals from the environment, or by a combination of withdrawals and recirculation. Obviously, the higher the rate of recirculation, the less impact economic processes have on the environment. Table 7.2 shows the use rate for each industry, calculated by dividing gross use by intake. It measures the number of times intake water is recirculated. All manufacturing industries recirculated water to some extent, although only six of the 21 industries in the manufacturing group recirculated intake water two or more times. Within this group, the plastic products industry showed the highest recirculation rate at 5.6 times. Considering all industries, the crude petroleum and natural gas industry had the highest recirculation rate of any industry (7.8).

Purpose of water use

Table 7.3 shows the use of water by purpose in selected industries. Process and sanitary water comes in direct contact with unfinished products, raw materials or wastes and therefore may contain chemical or solid residues on discharge. It includes water which is embodied in products. Cooling, condensing and steam water includes pass-through water used for cooling and condensing, air conditioning, and the creation of steam. It does not come in direct contact with process materials but, of course, is subject to temperature change (increased temperatures in water bodies can harm aquatic species and increase rates of evaporation). Even though it has a cooling function, quenching water is included in the former category because it comes in direct contact with the process materials. As mentioned previously, the extent to which pollutants (including waste heat) are discharged to the environment in waste water depends on pollution abatement practices.

Domestic use

Of water used within the home, around 75 percent is for bathroom and toilet use, 20 percent for laundry, and 5 percent for cooking/drinking (Environment Canada, 1992, p. 8). Lawn watering and other outdoor uses can be significant in summer. Pollutants contained in domestic waste water include organic materials (oxygen-demanding substances), viruses, refractory organics, detergents, phosphates, grease and oil, salts and solids (Manahan, 1984, p. 166). To the extent that sewage is inadequately treated (or not treated at all), these pollutants enter the aquatic environment. Of the 75 percent of the population served by sewage collection systems in 1991, 84 percent had some form of sewage treatment, while the remainder discharged wastewater di-

1. Statistical studies on waste emissions and pollution abatement expenditures are underway at Statistics Canada and will be reported on in the future.

rectly to receiving water bodies (Environment Canada, 1994, p. 3).

Agriculture

Except for thermal power, agriculture withdraws more water than any other industry and is by far the largest consumptive user of water. Water is used in agriculture for irrigation and for livestock production (drinking water, sanitation and waste disposal). Data for 1981 (the latest available Environment Canada estimates by purpose of use), show irrigation use to be 88 percent of total water use in agriculture. Irrigation, by nature, is concentrated in areas that experience dry seasonal conditions, a factor which heightens its impact on aquatic environments. Irrigation and its associated dam construction and diversion works affects stream flows and return water contains dissolved fertilizers, pesticides, salts and sulphates (Government of Canada, 1991, p. 3-10).

Thermal electricity industry

Although water use by purpose data are not available for this industry, nearly all water use is for condenser cooling, with relatively smaller amounts being used for boiler feed and purposes such as ash control and sanitation. As thermal power stations often employ once-through cooling systems, water is returned to the environment at a higher temperature than it is withdrawn, with consequential environmental impacts. Although the consumption rate is only 0.4 percent, it is relatively substantial in volume terms. The consumption rate would be higher if the increased evaporation from warmer receiving waters was taken into account.

Table 7.3
Water Use by Purpose for Selected Industries

	Process and sanitary use	Cooling, condensing and steam use	Total
	millions of cubic metres		
4 Mining	300.2	59.1	359.3
8 Food products	219.5	143.1	362.6
14 Primary textile and textile products	70.0	209.8	279.8
18 Paper and allied products	2 281.2	625.0	2 906.2
20 Primary metal products	674.4	908.7	1 583.1
26 Refined petroleum and coal products	53.0	386.4	439.4
27 Chemical and chemical products	201.5	1 096.9	1 298.4
All other manufacturing	358.5	282.3	640.8
Total manufacturing	**3 858.1**	**3 652.2**	**7 510.3**

Source:
Statistics Canada, National Accounts and Environment Division.

Mining

The predominant use of water in the mining industry (4) is process and sanitary use (84 percent). The composition of minewater effluent varies with the composition of the ore, but it is commonly acidic. Mineral concentration activity is a heavy user of water. Although process water is generally held in tailings ponds before release, the discharged water typically contains residues of ore and other waste minerals as well as small quantities of chemicals which can be highly toxic (Government of Canada, 1991, p. 3-12). The crude petroleum and natural gas industry (excluded from Table 7.3 because reliable estimates are not available for 1991) uses large amounts of water for condensing of natural gas, for heat extraction of crude from oil sands and for injection into wells to enhance oil recovery.

Paper and allied products industry

The paper and allied products industry (18) is a large water user and its impact on aquatic systems has been an increasing focus of attention in recent years. Water use is predominately for process purposes (76 percent). Water is used in cleaning and steaming wood chips and for adding to pulp to make a slurry from which paper is made. Effluent from mills include solid waste and chlorinated organic chemicals such as dioxins and furans, which are of particular concern as they have the propensity to bioaccumulate (Government of Canada, 1991, p. 3-12).

Primary metals industry

The primary metal products industry (20) is the second largest user of water in the manufacturing sector (after the paper and allied products industry), with the primary steel industries and non-ferrous smelting and refining industries accounting for over 90 percent of the water use. As an indication of water use in this industry, U.S. sources state that blast furnaces typically use around 42 cubic meters of water to produce one ton of iron, with additional amounts required to convert iron to steel (U.S. Geological Survey, 1987, p. 88). Cooling accounts for 57 percent of water use, the remainder being for process, sanitary and other purposes. Process use includes quenching, sintering, scale removal, and cleaning of blast furnaces. Wastewater can include contaminants such as suspended solids, metals, oil and grease, cyanide, ammonia, acids and phenols (Environment Ontario, 1991).

Refined petroleum and coal products industry

As petroleum refining uses heat to separate the various products from crude oil, the predominant use of water in this industry (26) is for cooling (the cooling, condensing and steam water use category represents 88 percent of total water use). However in volume terms, large amounts of process water is also used. Largely in response to federal effluent regulations and guidelines, the industry has dramatically reduced its liquid discharge of sulphides, ammo-

Table 7.4
Total Water Intensity of Commodities, 1991

		Self supplied	Municipal	Total intake	Gross use	Water consumed	Water discharged
		thousands of cubic metres per million dollars of output					
1,2	Grains and live animals	258.1	1.3	259.4	275.5	165.1	94.3
3	Other agricultural products	257.6	1.3	258.9	275.0	164.8	94.1
4	Forestry products	27.0	0.7	27.8	35.3	6.4	21.3
5	Fish landings	15.2	0.7	15.9	23.0	1.7	14.2
6	Hunting & trapping products	20.5	1.1	21.6	30.0	5.4	16.2
7	Iron ores & concentrates	100.7	2.2	103.0	217.0	1.0	102.0
8	Other metal ores & concentrates	106.1	2.7	108.8	221.9	1.6	107.2
9	Coal	100.7	2.2	103.0	216.9	1.0	102.0
10	Crude mineral oils	43.0	0.5	43.5	90.2	3.8	39.7
11	Natural gas	43.0	0.5	43.5	90.1	3.8	39.7
12	Non-metallic minerals	88.2	1.7	89.9	142.2	6.9	83.0
13	Services incidental to mining	38.0	0.9	38.9	52.5	1.9	37.0
14	Meat products	103.0	6.1	109.2	127.7	49.3	59.8
15	Dairy products	100.0	6.2	106.3	124.6	47.3	59.0
16	Fish products	99.5	6.2	105.7	123.9	47.0	58.7
17	Fruit & vegetable preparations	97.5	6.2	103.7	121.8	45.7	58.0
18	Feeds	97.2	6.1	103.3	121.2	45.7	57.7
19	Flour, wheat, meal & other cereals	100.1	6.2	106.4	124.7	47.3	59.0
20	Breakfast cereal & bakery products	93.7	5.7	99.5	116.6	42.8	56.7
21	Sugar	100.1	6.2	106.4	124.7	47.3	59.0
22	Miscellaneous food products	99.3	6.0	105.2	123.4	46.8	58.4
23	Soft drinks	41.3	9.3	50.6	65.7	8.1	42.5
24	Alcoholic beverages	39.1	9.4	48.5	63.4	6.6	41.9
25,26	Tobacco and cigarettes	58.0	2.1	60.2	73.1	24.1	36.0
27	Tires & tubes	45.9	4.1	50.0	83.4	2.2	47.8
28	Other rubber products	48.7	4.5	53.2	88.0	2.7	50.6
29	Plastic fabricated products	57.8	10.4	68.2	133.3	2.8	65.4
30	Leather & leather products	28.1	3.5	31.7	41.4	3.2	28.4
31	Yarns & man made fibres	91.3	6.7	98.0	148.8	8.5	89.5
32	Fabrics	90.0	6.7	96.6	146.7	8.4	88.2
33	Other textile products	87.7	6.5	94.2	143.1	8.1	86.1
34	Hosiery & knitted wear	27.8	2.9	30.7	42.4	1.9	28.8
35	Clothing & accessories	28.7	3.0	31.7	44.0	2.0	29.7
36	Lumber & timber	44.1	2.8	46.9	57.4	3.9	43.0
37	Veneer & plywood	43.8	2.8	46.6	57.0	3.9	42.7
38	Other wood fabricated materials	43.8	2.8	46.6	57.5	3.8	42.8
39	Furniture and fixtures	36.7	3.1	39.8	55.2	1.7	38.0
40	Pulp	244.0	9.1	253.1	390.0	11.9	241.3
41	Newsprint and other paper stock	243.0	9.1	252.1	388.4	11.8	240.3
42	Paper products	196.1	8.5	204.6	318.4	9.6	195.0
43	Printing & publishing	50.4	2.7	53.2	77.4	2.3	50.9
44	Advertising and print media	48.4	2.7	51.1	74.1	2.2	48.9
45	Iron & steel products	143.6	5.5	149.1	260.5	5.5	143.7
46	Aluminum products	151.2	5.6	156.8	274.8	5.8	151.0
47	Copper & copper alloy products	149.5	5.6	155.1	271.7	5.7	149.4
48	Nickel products	153.1	5.6	158.8	278.5	5.8	152.9
49	Other non ferrous metal products	140.7	5.5	146.2	255.0	5.5	140.7
50	Boilers, tanks & plates	45.8	4.6	50.4	77.0	1.7	48.7
51	Fabricated structural metal products	56.6	4.8	61.4	97.0	2.2	59.3
52	Other metal fabricated products	56.6	4.9	61.5	98.2	2.2	59.3
53	Agricultural machinery	29.1	3.6	32.7	47.2	1.5	31.2
54	Other industrial machinery	33.8	3.4	37.2	55.6	1.6	35.5
55	Motor vehicles	20.8	3.2	23.9	34.2	0.9	23.0
56	Motor vehicle parts	22.4	3.2	25.6	37.1	1.0	24.7
57	Other transport equipment	21.0	3.0	24.0	34.3	0.9	23.1
58	Household appliances & receivers	24.2	2.5	26.7	38.2	1.0	25.7
59	Other electrical products	22.4	2.4	24.8	35.1	1.0	23.8
60	Cement & concrete products	75.9	13.5	89.4	136.2	10.5	78.8

Table 7.4
Total Water Intensity of Commodities, 1991 (Concluded)

		Self supplied	Municipal	Total intake	Gross use	Water consumed	Water discharged
		thousands of cubic metres per million dollars of output					
61	Other non-metallic mineral products	71.6	12.5	84.1	128.1	9.7	74.4
62	Gasoline & fuel oil	60.8	1.7	62.5	143.8	3.9	58.6
63	Other petroleum & coal products	65.0	1.8	66.8	138.5	4.2	62.6
64	Industrial chemicals	116.6	4.5	121.1	188.2	7.0	114.1
65	Fertilizers	133.3	2.6	135.9	220.7	32.3	103.6
66	Pharmaceuticals	117.8	4.5	122.2	188.4	8.1	114.1
67	Other chemical products	113.1	4.6	117.7	180.5	8.6	109.1
68	Scientific equipment	30.3	2.5	32.8	47.4	1.3	31.5
69	Other manufactured products	40.5	3.4	43.9	68.6	2.1	41.9
70-72	Construction	21.2	1.5	22.8	33.7	1.7	21.0
73	Pipeline transportation	102.3	0.3	102.6	116.6	0.7	101.9
74	Transportation & storage	21.2	0.9	22.1	31.2	0.9	21.2
75-77	Radio, television, telephone and postal services	9.4	0.6	10.0	12.4	0.3	9.7
78	Electric power	1 069.7	0.5	1 070.2	1 202.3	4.3	1 066.0
79	Other utilities	1 070.0	0.5	1 070.5	1 202.5	4.3	1 066.2
80	Wholesale margins	24.0	1.4	25.4	33.8	2.3	23.1
81	Retail margins	41.0	1.1	42.1	49.7	1.0	41.1
82	Imputed rent, owner occupied dwellings	1.2	0.1	1.3	1.8	0.1	1.2
83	Other finance, insurance & real estate	31.2	0.5	31.7	37.2	0.6	31.1
84	Business services	10.4	0.8	11.2	14.0	0.4	10.8
85	Education services	39.0	0.9	39.9	47.2	0.8	39.1
86	Health services	10.5	2.0	12.5	15.2	0.5	12.0
87	Amusement & recreation services	29.7	5.6	35.3	41.0	1.8	33.5
88	Accommodation & food services	45.0	6.3	51.3	59.8	9.9	41.4
89	Other personal & miscellaneous services	32.9	2.2	35.2	42.8	1.1	34.1
90	Transportation margins	18.9	0.8	19.7	27.9	0.8	18.9
91	Operating, office, lab. & food supplies	38.4	2.2	40.7	58.7	4.6	36.1
92	Travel, advertising & promotion	26.5	2.1	28.7	38.8	2.6	26.1

Source:
Statistics Canada, National Accounts and Environment Division.

nia, nitrogen, oil and grease and total suspended solids since 1972 (Government of Canada, 1991, p. 3-12). Intake water is recirculated on average 3.3 times.

Chemical and chemical products industry

The chemical industry (27) is diverse and includes industrial organic and inorganic chemicals, plastics, pharmaceuticals, paints, soap and cleaning compounds, and toilet preparations. Eighty-four percent of water use is for cooling, condensing and steam. However in volume terms, the industry uses large amounts of process water for the production of chemicals, residues of which can be discharged in waste water. Process waste water could include acids, bases, suspended solids, oil and grease, organic carbons, and toxic pollutants such as metals, phenols, and chlorinated hydrocarbons (Environment Ontario, 1991). Intake water is recirculated 1.8 times.

Water requirements of commodities

Table 7.4 utilizes one of the main features of input-output modelling to show the total quantity of water required to produce a unit value of a commodity for delivery to final demand. This is referred to as an "impact" or "total requirements" table and includes both direct and indirect water requirements, the meaning of which can best be illustrated by an example. The direct water requirement for the production of a motor vehicle is the water used by the motor vehicle manufacturer per dollar of motor vehicle output. However the motor vehicle industry also has requirements for commodities as inputs, for example steel, electricity, components, and tires, all of which have their own direct water requirements. The steel manufacturer has requirements for water to produce the steel sold to the car manufacturer and so on. Therefore, the total water required to produce a motor vehicle is the sum of direct and indirect water requirements.

As expected, Table 7.4 shows that commodities which are primary to large water using industries also tend to have high water-use intensities per dollar unit of output. For ex-

ample, electric power requires 1.1 million cubic metres per million dollars produced and is by far the most water intensive commodity. In one sense, this actually understates the true water intensity of thermal electricity as the dollar value of output includes hydroelectricity (which does not "withdraw" water) in addition to thermal electricity. Agricultural commodities (1-3) and pulp (40), newsprint and other paper stock (41) all have a similar water intensity of approximately 250 thousand cubic metres per million dollars of output.

Total water intensity estimates are more interesting for higher order commodities that contribute substantially to final demand. For instance, motor vehicles (55) require 24 thousand cubic metres of water per million dollars of output. This is almost eleven times the amount of water used directly by the transportation equipment industry in the manufacture of its output. An extreme example of this multiplier affect is construction commodities (70-72), where water requirements are close to six hundred times the small amount of water used directly by the construction industry. High but less extreme multipliers are also evident for wholesale and retail trade margins (80-81), reflecting the high direct and indirect water use of inputs such as paper and energy (but excluding water use in the production of goods sold as they are excluded from the concept of margins).

Other commodities that make a substantial entry into final demand, and have a relatively high water intensity, include the various food categories (14-22) and pharmaceuticals (66). It is interesting to note that food products are over twice as water intensive as soft drinks and alcoholic beverages, despite the fact that the latter consist almost entirely of water.

A word of caution is necessary. Because of the way input-output tables are constructed, total water intensities derived for some commodities are not realistic. Where an industry produces more than one commodity, the water intensity of those commodities will be virtually the same and reflect the intensity of the industry's total output. For example, the water intensites shown for grains (1), live animals (2) and other agricultural commodities (3) should be viewed more as agricultural industry averages than as accurate measures of the water intensity of each commodity taken separately.

If the water-use intensities shown in Table 7.4 were multiplied by the value of final demand for each commodity, the result summed for all commodities would equal the total amount of water used by the business sector (as shown in Table 7.1). If a different set of final demands were postulated, the water requirements of that new level of production could be simulated, given certain standard assumptions required for input-output analysis. Similarly, a time series of total water intensity coefficients could be used to study the impact of changes in industry technologies on the water requirements of different commodities (for example, see Tate, 1986).

Domestic and government direct water use is not determined within the total water intensity model used to derive the estimates in Table 7.4 because both water supply and use for those sectors is contained within final demand. To the extent that water use is related to final expenditures, for example personal expenditure on gross imputed rent and various categories of government consumption expenditures (for example on hospitals, education and defence), these components could be internalised as direct co-efficients (water use per dollar of final expenditure). Alternatively, if analysis shows water use by these sectors to be more dependent on other variables, such as population or employment, it should best be determined outside the input-output model. This is the approach adopted in these estimates.

Conclusion

The state of Canada's water resources has been a key issue in the environmental debate for many years. Water use accounts provide a structured set of statistics at the national and provincial level that provide information on who is withdrawing water and how much, where it is coming from, what it is being used for, and the incidence of recirculation. The use of an input-output framework for the presentation of statistics is particularly suited for highlighting and analysing the interaction between economic activity and the environment. Work to extend the data set within this framework for earlier years (using Environment Canada and other sources) is underway. When that work is complete, it should be possible to draw some useful conclusions about trends in economy-environment (water use) interactions over time. Work planned for compiling waste accounts (including waste discharged in water) and pollution abatement statistics will add further to the information available within a consistent environmental accounting framework.

References

Environment Canada, 1986, ***Canada Water Year Book 1985: Water Use edition***.

______, 1991, ***MISA Water Pollution Abatement Technology and Cost Study***.

______, 1992, ***Water Conservation: Every Drop Counts***, Freshwater Series A-6.

______, 1993, ***Water Works!*** Freshwater Series A-4.

______, 1994, ***Urban Water***, SOE Bulletin No. 94-1.

Government of Canada, 1990, ***Canada's Green Plan for a Healthy Environment***.

______, 1991, ***The State of Canada's Environment***.

Manahan, S.E., 1984, ***Environmental Chemistry***, Brooks/Cole Publishing.

Renzetti, S.R., 1992, "Estimating the structure of Industrial Water Demands: The Case of Canadian Manufacturing", ***Land Economics,*** 68 (4).

Smith, R., 1991, ***The Linkage of Greenhouse Gas Emissions to Economic Activity Using an Augmented Input-Output Model,*** National Accounts and Environment Division, Discussion Paper No. 9, Statistics Canada, Hull.

Statistics Canada, 1994, ***Human Activity and the Environment 1994,*** Ottawa.

Tate, D.M., 1976, ***Water Use in Canadian Manufacturing Industry, 1972,*** Social Science Series, Inland Waters Directorate, Environment Canada.

______, 1985, ***Alternative Futures of Canadian Water Use, 1981-2011***, Inquiry on Federal Water Policy, Research Paper 17, Inland Waters Directorate, Environment Canada, Hull.

______, 1986, "Structural Change Implications for Industrial Water Use", ***Water Resources Research***, 22 (11).

Tate, D. M. and Scharf D. N., 1981, 1986, 1991, ***Water Use in Canadian Industry,*** Social Science Series, Water and Habitat Conservation Branch, Environment Canada, Ottawa.

Tate, D. M., Renzetti S., Shaw H.A., 1992, ***Economic Instruments for Water Management: The Case for Industrial water Pricing***, Social Science Series No. 26, Economics and Conservation Branch, Environment Canada, Ottawa.

U.S. Bureau of the Census, 1986, ***1982 Census of Manufacturers***, Subject series: Water Use in Manufacturing.

U.S. Geological Survey, 1987, ***National Water Summary 1987: Hydrological Events and Water Supply and Use,*** Water Supply Paper 2350.

Victor, P. A., 1972, ***Pollution, Economy and Environment,*** George Allen and Unwin Ltd.

8 Canadian Carbon Dioxide Emissions

by Robert Smith

Introduction

This chapter is an update of the greenhouse gas emissions study that was published in the previous edition of ***Environmental Perspectives: Studies and Statistics*** (Smith, 1993). While the earlier study presented emissions data for a number of greenhouse gases, but covered the year 1985 only, this paper focuses on carbon dioxide emissions only, but covers the entire period from 1981 to 1990. Data on other greenhouse gases were not sufficiently developed at the time of publication to be included here. Future work at Statistics Canada will include the development of time-series data for the other greenhouse gases, as well as for a range of other wastes.

The development of greenhouse gas emissions data at Statistics Canada has been undertaken as part of the development of a broader waste output account. This account will contain quantitative information on a wide range of waste materials generated by Canadian businesses, governments and households. The information will be organised into an accounting framework that will allow the linkage of the waste output data with the detailed economic information held by Statistics Canada. This linkage will allow the calculation of indicators of the waste intensity of Canadian economic activity, which, when compared over time, will provide useful insight into the development of the Canadian economy with respect to its demands on the environment as a sink for waste materials.

Before moving on to present the carbon dioxide emissions estimates for 1981 to 1990, it is useful as background information to discuss the relationship between carbon dioxide emissions and the greenhouse effect.

Carbon dioxide emissions and the greenhouse effect

The greenhouse effect is a naturally occuring phenomenon in which certain trace atmospheric gases, carbon dioxide being the most important, trap some of the sun's heat between the earth's surface and atmosphere before it can be reflected from the surface back into outer space. In this way, these gases act just like the glass covering on a greenhouse.

The current concern about the greenhouse effect is not that it is, in itself, an environmental threat. Indeed, it is largely as a result of this phenomenon that surface temperatures on the planet are kept within the range suitable for life. Rather, the concern about the greenhouse effect stems from the fact that human activities are significantly increasing the atmospheric concentrations of greenhouse gases, particularly carbon dioxide. Scientists believe that these increased concentrations will significantly enhance the naturally occurring greenhouse effect during the coming decades.[1] If this expected enhancement does occur there may be significant environmental consequences. Among the possible effects of an enhanced greenhouse effect are an increase of up to 3-4˚C in the average global temperature; sea level rise of 0.5-1 metres, causing inundation of coastal regions; disruption of climatic patterns, with increased frequency of droughts and severe storms in some regions; and changes in habitat conditions so rapid that plant and animal species will be unable to adapt (Government of Canada, 1991). Alongside these predictions of negative consequences, some individuals note also that there may be economic benefits from an enhanced greenhouse effect, particularly from increased productivity of agriculture in some areas. Although the ultimate consequences of an enhanced greenhouse effect are still under debate, there is no doubt among scientists that carbon dioxide will be the most important gas in contributing to whatever changes do occur.

A colourless, odourless gas, carbon dioxide is the weakest of the greenhouse gases emitted from human activities in terms of its ability to absorb heat.[2] Nevertheless, it is the most significant in terms of its total contribution to the greenhouse effect. The International Energy Agency reports that 61 percent of the enhancement to the greenhouse effect predicted to take place over the next 100 years can be attributed to carbon dioxide emissions from global human activities. The contributions of the other major greenhouse gases are as follows: methane: 15 percent; chlorofluorocarbons: 11.5 percent; nitrous oxide: 4 percent; and others: 8.5 percent. Carbon dioxide's importance as a contributor to the greenhouse effect stems from its relatively high atmospheric concentration and long lifetime in comparison to the other greenhouse gases. One molecule of carbon dioxide will persist in the atmosphere for 50 to 200 years[3] and the average concentration of the gas was estimated to be 357 ppmv[4] in 1990. The latter has steadily increased from a pre-1800 value of approximately 280 ppmv and was in-

1. Although some evidence of the enhanced greenhouse gas effect has already been noted, an unequivocal demonstration of it is not expected for at least another decade (Intergovernmental Panel on Climate Change, 1992).
2. The family of chemicals known as the chlorofluorocarbons are the strongest gases in this regard.
3. The atmospheric lifetime of carbon dioxide is defined as the time required for carbon dioxide concentrations to equilibrate after a one-time surge in emissions. The large range in the reported lifetime is due to imperfect understanding of the carbon cycle (Houghton, *et al.*, 1990, p. 7).
4. ppmv = parts per million by volume.

creasing in 1990 at a rate of about 0.5 percent, or 1.8 ppmv, annually (International Energy Agency, 1991, p. 14-15).

Carbon dioxide is produced in very large quantities by human activities, principally from two sources. The combustion of fossil fuels (coal, oil and natural gas) is the most important source. The use of biomass associated with the production and consumption of wood, paper and agricultural products is the other main source. Production of cement, ammonia and natural gas, as well as the use of lubricants and petroleum feedstocks, contribute a few percent of the total carbon dioxide releases from human activities.

The annual release of carbon dioxide from global fossil fuel combustion and cement manufacturing has increased from less than 0.37 Gt in 1860 to 118 Gt in 1987.[1] The cumulative release of carbon dioxide from these sources during this period is estimated to have been 732 Gt ± 10 percent.

Ninety five percent of fossil fuel-related carbon dioxide emissions originate in the northern hemisphere, mainly in the industrialised nations. While per capita carbon dioxide emissions from fossil fuel combustion in the developing nations are substantially below those in industrialised nations (2.2 t versus 18.3 t), the rate of increase is much larger in the developing countries. During the 1970s and 1980s, per capita emission rates increased annually at a rate of approximately 6 percent in developing countries versus 1 to 3 percent in industrial economies (Houghton, *et al.*, 1990, p. 10).

Carbon dioxide emissions from biomass use are associated with a number of activities: forest burning during land clearing (mainly in tropical areas); decay of wastes from logging activities; decay of wood and paper products; and oxidation of organic matter found in soil resulting from agriculture and forestry activities. As the regrowth of forests and the redevelopment of organic matter in soil both remove carbon dioxide from the atmosphere, biomass represents both a source of carbon dioxide emissions as well as a store (sink) into which the gas is absorbed out of the atmosphere. The total release of carbon dioxide to the atmosphere from biomass sources between 1850 and 1985 is estimated to have been 421 Gt ± 30 percent. In the nineteenth and early twentieth centuries, most of the biomass-related carbon dioxide emissions were a result of forest harvesting in temperate regions, including Canada. Since the middle part of this century, however, the major source has been deforestation in the tropics. Over the entire period, the release of carbon dioxide from tropical regions is estimated to have been two to three times that from temperate regions (Houghton, *et al.*, 1990, p. 10-11).

Canada is responsible for approximately 2 percent of current annual global carbon dioxide emissions (excluding biomass sources, which are very difficult to estimate). Fossil fuel production and consumption[2] accounts for 97 percent of these emissions, with the remainder coming from the production of cement, lime, ammonia and natural gas, and the use of lubricants and petroleum feedstocks (Jaques, 1992, p. *xviii*).

1. Gt = gigatonnes
2. Consumption includes the use of fossil fuels for non-energy purposes.

Fossil fuels and carbon dioxide emissions

As just noted, fossil fuel use is responsible for nearly all of Canada's carbon dioxide emissions. Not all fossil fuels are created equal in terms of their contribution to these emissions. Text Box 8.1 below shows that there is significant variation among the fossil fuels in terms of carbon dioxide emissions. At the low end of the scale is natural gas, which emits approximately 50 tonnes of carbon dioxide per terajoule burned.[3] The various forms of coal and coke are found at the high end of the scale, with emission factors in the range of approximately 82 t/TJ to 100 t/TJ. The impact of this variability in unit carbon dioxide emissions on total Canadian emissions from fossil fuel combustion will become clear in the discussion that follows.

Carbon dioxide emission estimates, 1981-1990

Estimates are presented in Table 8.1 for the combined Canadian emissions of carbon dioxide from the combustion of fossil fuels and from the production of cement, lime, ammonia and natural gas, plus non-energy uses of petroleum products.[4] The data show that total carbon dioxide emissions in the economy varied during the period 1981-1990 from a low of 387 megatonnes in 1983 to a high of 490 meg-

3. The joule (J) is the basic unit of energy measure; a terajoule (TJ) is 10^{12}, or one thousand billion, joules. A 40 litre tank of gasoline contains approximately 1.36 billion joules.
4. The estimates do not include biomass emissions because of the high degree of uncertainty associated with their estimation.

Text Box 8.1
Carbon Dioxide Emission Factors for Fossil Fuel Combustion

Fuel type	Carbon dioxide emission factor (tonnes/terajoule)
Natural gas	49.68
Still gas	49.68
Automobile gasoline	67.98
Kerosene	67.65
Aviation gasoline	69.37
Liquified petroleum gases	59.84 - 61.38
Diesel oil	70.69
Light fuel oil	73.11
Heavy fuel oil	74.00
Aviation turbo fuel	70.84
Petroleum coke	100.10
Coal coke	86.00
Anthracite coal	86.20
U.S. bituminous coal	81.60 - 85.90
Canadian bituminous coal	83.00 - 94.30
Sub-bituminous coal	94.30
Lignite coal	93.80 - 95.00

Source:
Jaques, 1992, p. *xx*.

Table 8.1
Carbon Dioxide Emissions by Sector, 1981-1990

		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		kilotonnes									
Business sector											
1	Agricultural and related services	11 130	9 705	14 381	8 934	9 555	9 934	9 646	10 497	11 949	12 440
2	Fishing and trapping	1 240	1 239	1 027	1 103	1 121	1 145	1 031	1 119	1 307	1 263
3	Logging and forestry	2 040	1 453	1 668	1 575	1 985	2 521	2 303	2 341	2 026	2 700
4	Mining	7 438	4 820	5 673	6 233	6 508	6 289	7 905	9 027	8 684	6 964
5	Crude petroleum and natural gas	18 880	21 387	21 759	23 712	25 798	28 224	31 075	32 754	35 928	35 241
6	Quarries and sand pits	463	513	415	408	456	593	707	908	818	534
7	Services related to mineral extraction	2 349	2 065	1 751	1 969	2 225	1 667	1 527	2 195	1 483	1 344
	Sub-total, primary resource industries (1-7)	**43 540**	**41 182**	**46 674**	**43 934**	**47 648**	**50 373**	**54 194**	**58 841**	**62 195**	**60 486**
8	Food products	4 220	4 119	3 834	3 650	3 902	4 169	4 777	4 418	4 252	3 949
9	Beverages	1 069	983	843	826	848	853	858	832	812	728
10	Tobacco products	59	58	45	46	50	51	42	49	52	51
11	Rubber products	480	292	412	393	412	419	454	401	419	364
12	Plastic products	298	285	252	252	279	311	379	501	521	476
13	Leather and allied products	88	73	79	86	99	88	83	84	65	57
14	Primary textile and textile products	1 528	1 216	1 244	1 146	1 003	1 071	1 239	1 408	1 332	1 228
15	Clothing	167	150	161	160	189	221	242	300	206	223
16	Wood products	1 751	1 489	1 627	1 662	1 672	1 527	2 150	2 038	2 072	1 485
17	Furniture and fixtures	219	213	199	209	282	290	365	384	416	355
18	Paper and allied products	15 031	10 265	12 110	11 461	10 650	10 734	10 412	10 940	12 753	14 322
19	Printing, publishing and allied	278	268	273	276	369	393	454	531	543	478
20	Primary metal products	26 454	21 299	22 468	25 565	26 180	26 902	26 979	27 323	27 210	21 570
21	Fabricated metal products	1 466	1 363	1 271	1 452	1 613	1 640	1 901	2 175	2 184	1 861
22	Machinery	630	600	492	517	616	583	701	788	719	699
23	Transportation equipment	1 862	1 773	1 842	1 919	2 387	2 348	2 596	3 039	3 202	2 344
24	Electrical and electronic products	1 138	874	800	1 436	1 091	1 623	1 370	1 160	1 143	1 019
25	Non-metallic mineral products	13 367	11 066	10 321	11 010	11 423	12 848	14 790	15 507	15 655	14 015
26	Refined petroleum and coal products	21 401	18 347	17 172	18 777	19 693	17 918	22 800	21 673	22 094	22 624
27	Chemical and chemical products	17 682	17 789	18 843	20 394	20 256	18 181	19 166	21 129	18 701	17 510
28	Other manufacturing industries	345	310	279	297	362	397	420	478	447	433
	Sub-total, manufacturing industries (8-28)	**109 533**	**92 832**	**94 567**	**101 534**	**103 376**	**102 567**	**112 178**	**115 158**	**114 798**	**105 791**
29	Construction	8 192	7 265	6 152	6 514	7 392	6 911	7 914	8 005	7 823	6 545
30	Transportation	32 565	27 723	28 984	30 134	32 952	33 580	33 873	39 161	40 592	37 827
31	Pipeline transport	4 059	3 652	2 410	3 322	4 464	3 938	4 694	6 230	6 699	6 693
32	Storage and warehousing	265	286	225	375	390	349	403	370	415	408
33	Communications	1 190	1 220	1 063	1 173	1 344	1 195	1 136	1 219	1 160	1 052
34	Electric power and other utilities	70 634	77 130	76 672	83 017	84 334	77 710	88 720	98 068	110 103	95 627
35	Wholesale trade	7 216	6 537	6 008	6 674	6 997	6 595	6 754	7 321	7 342	7 381
36	Retail Trade	7 930	7 528	6 937	7 498	7 766	7 551	7 309	7 575	7 476	7 756
37	Finance and Real Estate	8 121	9 038	8 967	8 295	9 620	10 665	9 068	9 110	9 301	10 797
38	Insurance	303	250	220	151	150	168	163	208	188	180
41	Business services	1 151	1 124	1 011	1 096	1 328	1 511	1 446	1 544	1 578	1 612
42	Educational services	202	214	197	229	272	229	239	241	290	324
43	Health services	1 157	1 164	1 009	1 187	1 193	1 191	1 262	1 095	1 163	1 298
44	Accommodation and food services	3 814	3 627	3 276	3 583	3 702	3 361	2 639	2 687	2 843	3 096
45	Amusement and recreational services	401	395	327	356	392	457	390	383	443	576
46	Personal and household service	1 043	1 031	867	908	939	1 029	867	808	856	1 080
47	Other service	1 481	1 401	1 313	1 428	1 605	1 689	1 712	1 788	1 857	1 794
48	Operating, office, cafeteria and laboratory supplies	65	67	76	48	46	41	33	40	37	45
49	Travel, advertising and promotion	5 458	4 651	4 300	4 807	4 534	4 698	3 592	3 687	3 201	3 755
	Sub-total, service industries (32,33,35-49)	**39 797**	**38 533**	**35 796**	**37 808**	**40 278**	**40 729**	**37 013**	**38 076**	**38 150**	**41 154**
	Sub-total, business sector (1-49)	**308 320**	**288 317**	**291 255**	**306 263**	**320 444**	**315 808**	**338 586**	**363 539**	**380 360**	**354 123**
Personal sector											
	Home heating	45 366	47 973	37 063	38 434	39 265	38 705	33 867	37 891	41 013	38 557
	Motor fuels and lubricants	46 940	44 326	41 083	40 576	42 954	43 034	45 949	49 343	52 519	51 209
	Other personal sector activities	2 686	2 741	2 511	2 702	2 642	2 901	3 010	2 752	3 377	3 554
Government sector											
	Hospitals	1 671	1 712	1 474	1 323	1 262	1 252	940	610	697	1 048
	Education	4 771	4 681	3 871	3 723	3 368	3 205	3 174	2 767	3 201	3 818

Table 8.1
Carbon Dioxide Emissions by Sector, 1981-1990 (Concluded)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	kilotonnes									
Defence	3 640	3 376	2 585	2 888	2 662	2 596	1 994	2 361	2 574	2 530
Other government activities	8 073	8 037	7 048	7 632	7 920	7 988	6 824	7 132	6 424	5 612
Sub-total, personal and government sectors	**113 147**	**112 846**	**95 635**	**97 278**	**100 073**	**99 681**	**95 758**	**102 856**	**109 805**	**106 328**
Total, whole economy	**421 466**	**401 165**	**386 892**	**403 539**	**420 519**	**415 490**	**434 348**	**466 396**	**490 169**	**460 450**

Note:
The total carbon dioxide emission estimate for 1985 reported here is higher than the figure published in the previous edition of ***Environmental Perspectives: Studies and Statistics*** (Smith, 1993). This is due to revisions in the energy data that were used to derive the estimates. In particular, producer consumption of natural gas by the crude petroleum and natural gas industry is included in the current study, whereas it had been improperly excluded in the earlier study.
Source:
Statistics Canada, National Accounts and Environment Division.

atonnes in 1989. On average during this period, the business sector accounted for 76 percent of total carbon dioxide emissions. Household emissions represented 21 percent of the total on average, and government activities accounted for the remaining 3 percent.

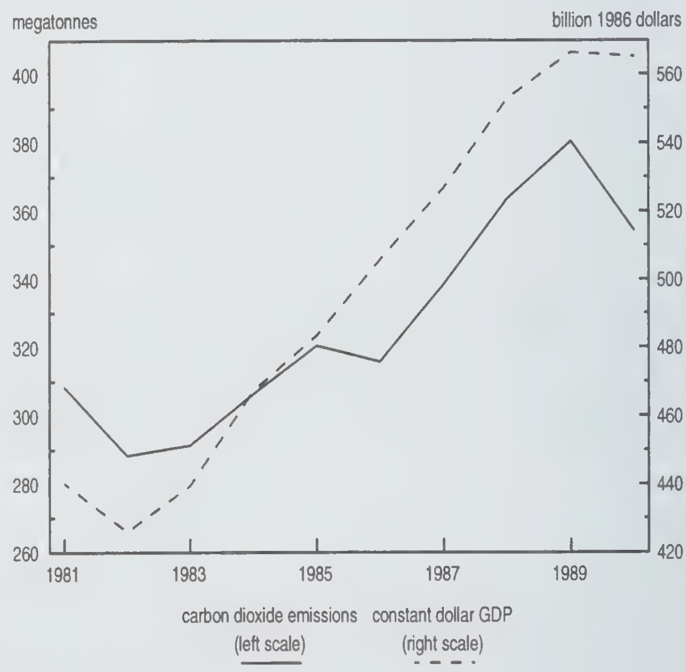
Within the business sector, the manufacturing industries (industries 8 to 28 in Table 8.1) accounted for the largest portion of carbon dioxide emissions in all years. Despite maintaining this leading position, over the period in question the manufacturing industries' share of business sector carbon dioxide emissions actually fell from 36 percent to 30 percent. The next largest contributor to business sector emissions, the electric power and other utilities industry (34), saw its share of emissions increase from 23 percent to 27 percent between 1981 and 1990. The carbon dioxide emissions from this industry are mainly the result of the use of fossil fuels, principally coal, to generate electricity in many parts of the country. The primary resource industries (1 through 7) accounted for 14 percent of emissions in 1981; this share had increased to 17 percent by 1990. The service industries (32, 33 and 35 to 49) made up 13 percent of emissions in 1981 and 12 percent in 1990. Finally, the for-hire transportation industries (truck, rail, marine, air, urban and pipeline transport) accounted for 12 and 13 percent of emissions in 1981 and 1990 respectively.[1]

Household sector[2] emissions were split fairly evenly between home heating and private transportation activities during the first half of the 1980s. In later years, however, transportation emissions dominated, as home heating emissions fell by 15 percent from 1981 to 1990. This decline was the result of decreased use of oil for home heating purposes in favour of both electricity and natural gas (Statistics Canada, 1992). Household transportation emissions fell from 1981 to 1986 by over 8 percent, but rose again by nearly 19 percent by 1990.

1. The for-hire transportation industries do not represent all transportation that takes place in the business sector. There is also transportation undertaken by businesses on their own account (private truck fleets for example). Thus, as an activity, transportation accounts for more carbon dioxide emissions than the 12-13 percent that are attributable to the for-hire industries alone.
2. The household sector includes non-profit organisations and unincorporated businesses as well as private households.

Business sector carbon dioxide emissions are plotted along with business sector constant dollar Gross Domestic Product (GDP)[3] in Figure 8.1. The figure shows a direct relationship between carbon dioxide emissions and GDP in most years. The year 1986 differs in this regard however, with carbon dioxide emissions falling while GDP was rising rapidly.

Figure 8.1
Business Sector Carbon Dioxide Emissions and Gross Domestic Product, 1981-1990



Source:
Statistics Canada, National Accounts and Environment Division.

The decline in business sector carbon dioxide emissions witnessed in 1986 was due in part to a continual shift by many industries away from petroleum and coal products to-

3. Business sector GDP is the portion of domestic production accounted for by activity in the business sector. On average, during the 1980s this portion was about 80 percent of total GDP.

Table 8.2
Business Sector Fossil Fuel Consumption, 1981-1990

Industry group	Fossil fuel type	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		percent of total (unless otherwise noted)									
Primary resource	Coal and coke	1.0	0.9	0.9	1.0	1.3	1.6	3.8	3.8	3.4	1.8
	Petroleum products	49.1	40.0	45.8	37.2	37.3	35.0	30.3	31.9	29.7	33.8
	Natural gas	49.9	59.1	53.3	61.8	61.4	63.4	65.9	64.4	66.9	64.4
	Total fossil fuel consumption (TJ)	**644**	**628**	**733**	**701**	**721**	**772**	**831**	**890**	**937**	**923**
Manufacturing	Coal and coke	13.0	14.1	14.6	13.9	15.1	14.5	14.3	14.7	14.4	13.9
	Petroleum products	41.8	37.5	35.7	34.9	30.2	31.1	33.1	30.2	31.0	32.6
	Natural gas	45.2	48.4	49.7	51.2	54.7	54.5	52.7	55.1	54.6	53.5
	Total fossil fuel consumption (TJ)	**1 416**	**1 229**	**1 255**	**1 288**	**1 315**	**1 265**	**1 429**	**1 474**	**1 493**	**1 387**
Construction	Coal and coke	1.9	2.3	2.2	2.2	2.2	2.2	0.6	0.5	0.7	-
	Petroleum products	97.1	96.7	96.7	96.7	96.8	96.9	98.3	97.8	97.7	98.2
	Natural gas	1.0	1.0	1.1	1.1	1.0	0.9	1.1	1.6	1.6	1.8
	Total fossil fuel consumption (TJ)	**120**	**107**	**93**	**99**	**107**	**99**	**114**	**116**	**111**	**95**
For-hire transportation	Coal and coke	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
	Petroleum products	81.6	80.7	85.9	83.1	80.5	82.5	80.6	79.4	77.9	76.7
	Natural gas	18.4	19.2	14.0	16.9	19.4	17.5	19.4	20.6	22.1	23.3
	Total fossil fuel consumption (TJ)	**554**	**481**	**483**	**523**	**563**	**557**	**575**	**679**	**700**	**681**
Services	Coal and coke	-	-	-	0.1	0.1	0.1	-	-	-	-
	Petroleum products	69.0	66.4	63.4	66.3	63.0	64.0	62.5	60.5	60.5	61.8
	Natural gas	31.0	33.5	36.5	33.6	36.9	35.9	37.5	39.4	39.5	38.1
	Total fossil fuel consumption (TJ)	**661**	**645**	**621**	**656**	**676**	**675**	**623**	**646**	**657**	**714**
Electric power	Coal and coke	84.1	85.6	90.2	92.3	91.5	91.8	88.3	86.9	77.6	81.4
	Petroleum products	9.9	9.8	6.1	5.3	6.1	6.2	9.2	9.7	13.7	13.9
	Natural gas	6.1	4.6	3.7	2.4	2.4	2.0	2.5	3.4	8.7	4.7
	Total fossil fuel consumption (TJ)	**835**	**906**	**915**	**988**	**953**	**866**	**990**	**1 099**	**1 244**	**1 074**
Total business sector	Coal and coke	21.2	24.0	24.8	25.9	25.0	23.5	24.4	24.6	23.6	22.3
	Petroleum products	47.6	43.1	42.4	40.6	39.4	40.3	39.0	38.3	38.1	40.4
	Natural gas	31.2	33.0	32.8	33.5	35.6	36.3	36.6	37.1	38.3	37.3
	Total fossil fuel consumption (TJ)	**4 230**	**3 996**	**4 100**	**4 255**	**4 335**	**4 234**	**4 562**	**4 904**	**5 142**	**4 873**
Business sector GDP (billion 1986 dollars)		320	304	312	336	356	367	382	407	415	410
Fossil fuel consumption per unit of GDP (TJ per billion 1986 dollars)		13.22	13.16	13.12	12.67	12.19	11.55	11.93	12.06	12.40	11.88

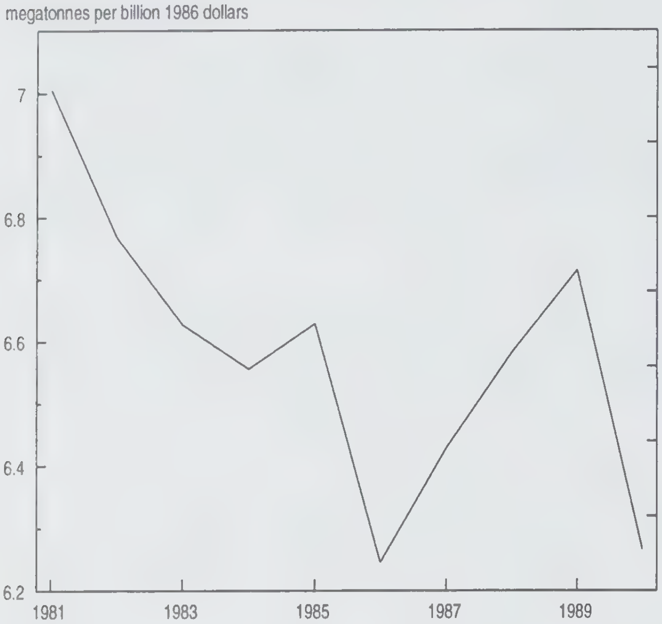
Source:
Statistics Canada, National Accounts and Environment Division.

ward natural gas between 1981 and 1986 (Table 8.2). In 1981, coal, coke and petroleum products taken together represented 68.8 percent of total business sector fossil fuel consumption; by 1986 this figure had fallen to 63.8 percent. In contrast, natural gas rose from 31.2 percent of fossil fuel consumption in 1981 to 36.3 percent in 1986. Since natural gas emits considerably less carbon dioxide per unit of energy than petroleum and coal products (Text Box 8.1), this shift in the composition of energy use exerted a downward force on carbon dioxide emissions. In 1986 this compositional shift was coupled with negative growth in total fossil fuel consumption. The result was the reduction in total carbon dioxide emissions seen for that year in Figure 8.1.

The shift away from petroleum to natural gas and the general low growth in fossil fuel demand in the middle 1980s were at least partly the results of substantial increases in the price of domestic crude oil that occurred from 1981 to 1986 (Hamilton, 1993). The move away from petroleum to natural gas actually began coincidently with a 40 percent increase in the average wellhead price of western Canadian crude oil in 1982. This price increase occurred just at the time when the economy was entering the economic recession of 1982. The combined result of these events was a fall in business sector fossil fuel consumption of 5.8 percent between 1981 and 1982 and the corresponding drop in carbon dioxide emissions shown in Figure 8.1. The recession ended in 1983, but crude oil prices continued to rise, reaching an all-time high in 1985 only to fall again by almost one half the next year. This major price reduction was responsible - along with strong economic growth - for a 21.9 percent increase in fossil fuel consumption by businesses between 1986 and 1989. As seen in Figure 8.1, business sector carbon dioxide emissions also rose very substantially between 1986 and 1989.

Figure 8.2 shows a plot of business sector carbon dioxide emissions per unit of constant dollar GDP. This ratio can be interpreted as an overall carbon dioxide intensity measure for business sector production. The figure shows a distinct contrast between the period 1981-1986, when this intensity fell by nearly 11 percent, and the period 1986-1989, when it rose again by over 7 percent. Data in the last row of Table 8.2 show that fossil fuel use per unit of GDP in the business sector followed this same trend. The fact that the fossil fuel (and carbon dioxide) intensity of overall production fell during the early years of the 1980s, when petroleum prices were rising rapidly, implies that businesses were in general able to reduce their fossil fuel consumption in order to reduce their fuel costs, while at the same time increasing their

Figure 8.2
Business Sector Carbon Dioxide Emissions per Unit of Gross Domestic Product, 1981-1990



Source:
Statistics Canada, National Accounts and Environment Division.

output. However, these reductions appear not to have been entirely maintained after the 1986 fall in petroleum prices, as the fossil fuel intensity (as well as carbon dioxide intensity) of production began to climb again after 1986. It is significant, however, that neither fossil fuel intensity nor carbon dioxide intensity had regained its level of the early 1980s by 1989. 1990 saw a fall in both of these intensities as a result of the recession that began in that year.

Carbon dioxide intensity of commodity production, 1981-1990

Table 8.3 presents carbon dioxide intensity estimates for 92 commodities or commodity groups representing the entire range of goods and services offered in the Canadian economy. Table 8.4 presents energy intensity estimates for the same group of commodities.[1,2]

The intensities shown in these two tables are measures of the *direct* and *indirect* carbon dioxide emissions (energy use) associated with one thousand dollars of production for each commodity. Direct emissions (energy use) in this context are those associated with the production of the commodity itself, while indirect emissions (energy use) are those associated with the production of the goods and services used as inputs by the commodity-producing industry. Text Box 8.2 presents a simple example to help clarify this distinction.

There are a number of factors that will influence the intensity measures for a given commodity. Most obviously, total fossil fuel consumption per unit of production has a major impact on both energy intensity and on carbon dioxide intensity. The most important factor affecting the quantity of fuel consumed per unit of production is the technology employed in making the commodity. There are two relevant aspects of a given technology in this regard. First, there is the efficiency of the energy-using equipment employed in the process. As this efficiency changes, all other things equal, so too will the carbon dioxide/energy intensity of production. Second, there is the relative importance of energy versus other inputs (labour, capital, materials) in the process. A giv-

Text Box 8.2
Direct Versus Indirect Waste Emissions

In the production of any product a certain amount of waste is created by the producing industry; this is what is referred to here as a *direct* waste output. For example, the carbon dioxide emissions from chemical plants are "direct" emissions associated with the production of industrial chemicals. The waste associated with chemical production is not just that which comes directly from chemical plants however. In order to make their products, chemical manufacturers must first purchase machinery, fuel, feedstocks and a variety of other inputs from suppliers. All of these products have waste emissions associated with their production that can be *indirectly* attributed to the chemical industry in proportion to its purchases of the products. If, for example, the chemical industry purchases 2 percent of the electric power industry's production, then 2 percent of the carbon dioxide emissions associated with electric power can be indirectly attributed to the chemical industry. Consideration of both types of emissions - direct and indirect - gives a complete picture of the waste emissions embodied in the production of products. The same distinction can be applied to energy use, or the use of any resource input for that matter (for a discussion of the water intensity of production of Canadian industries, see Chapter 7). Direct energy use is that by the industry producing a commodity; indirect energy use is that by the industries producing the inputs used by the producing industry.

1. A note of caution is in order in interpreting the data presented in Tables 8.3 and 8.4. In many instances, a given industry produces more than one commodity. For example, both grains and live animals are produced by the agriculture industry. In these cases, the intensity of the co-produced commodities will be identical (or nearly so), and will reflect the average intensity of one unit of "production" from the industry regardless of the proportion in which each of the commodities is represented in this production. In these cases, the commodities have been reported together in Tables 8.3 and 8.4.
2. The energy intensity estimates include both fossil fuel and electricity use.

Table 8.3

Carbon Dioxide Intensity of Commodity Production, 1981-1990

Commodity		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		tonnes per thousand 1986 dollars									
1,2	Grains and live animals	1.0957	1.0094	1.2585	0.9530	1.0068	0.9570	0.9950	1.0693	1.1250	1.0411
3	Other agricultural products	1.0933	1.0087	1.2535	0.9517	1.0057	0.9574	0.9911	1.0597	1.1130	1.0342
4	Forestry products	0.8783	0.7665	0.7192	0.6642	0.7574	0.8487	0.7645	0.7492	0.7171	0.8100
5	Fish landings	1.2608	1.2419	1.1135	1.2507	1.0762	1.0514	1.0410	1.0376	1.0805	1.0154
6	Hunting and trapping products	1.2618	1.2419	1.1134	1.2507	1.0762	1.0514	1.0410	1.0364	1.0805	1.0155
7	Iron ores and concentrates	1.3517	1.1702	1.2413	1.0813	1.0969	1.1154	1.2179	1.2662	1.2459	1.0553
8	Other metal ores and concentrates	1.4286	1.3203	1.3632	1.1895	1.2287	1.2704	1.3528	1.3322	1.3031	1.1191
9	Coal	1.3497	1.1674	1.2392	1.0782	1.0966	1.1154	1.2179	1.2665	1.2429	1.0561
10	Crude mineral oils	1.4469	1.5794	1.5138	1.5662	1.5760	1.7763	1.8481	1.7835	1.9410	1.8799
11	Natural gas	1.4473	1.5842	1.5206	1.5726	1.5837	1.7802	1.8475	1.7830	1.9401	1.8790
12	Non-metallic minerals	1.3108	1.3593	1.2837	1.2190	1.2034	1.2633	1.3310	1.3733	1.3816	1.2351
13	Services incidental to mining	0.9718	0.9366	0.8885	0.8597	0.8656	0.8597	0.9082	0.9964	0.9063	0.8038
14	Meat products	0.7832	0.7503	0.8124	0.6949	0.7032	0.6984	0.7240	0.7464	0.7768	0.7210
15	Dairy products	0.7852	0.7476	0.8139	0.6942	0.6998	0.6992	0.7252	0.7480	0.7793	0.7224
16	Fish products	0.7867	0.7494	0.8163	0.6968	0.7019	0.7010	0.7274	0.7503	0.7818	0.7246
17	Fruit and vegetable preparations	0.7803	0.7438	0.8064	0.6893	0.6941	0.6926	0.7180	0.7412	0.7691	0.7129
18	Feeds	0.7896	0.7566	0.8127	0.6947	0.6986	0.6955	0.7173	0.7379	0.7706	0.7117
19	Flour, wheat, meal and other cereals	0.7849	0.7468	0.8142	0.6943	0.7000	0.6995	0.7255	0.7481	0.7801	0.7231
20	Breakfast cereal and bakery products	0.7666	0.7248	0.7812	0.6708	0.6828	0.6806	0.6995	0.7122	0.7404	0.6897
21	Sugar	0.7849	0.7468	0.8142	0.6943	0.7000	0.6995	0.7255	0.7486	0.7798	0.7226
22	Miscellaneous food products	0.7844	0.7458	0.8092	0.6925	0.7006	0.6961	0.7197	0.7459	0.7777	0.7220
23	Soft drinks	0.6267	0.6217	0.6000	0.5759	0.5729	0.5893	0.5861	0.5711	0.5599	0.5234
24	Alcoholic beverages	0.6263	0.6209	0.5993	0.5756	0.5726	0.5891	0.5858	0.5646	0.5514	0.5155
25, 26	Tobacco and cigarettes	0.4992	0.4643	0.4852	0.4594	0.4239	0.4727	0.3901	0.3993	0.4516	0.4395
27	Tires and tubes	0.7480	0.7051	0.7081	0.6371	0.6081	0.6091	0.6178	0.5871	0.5787	0.5217
28	Other rubber products	0.7109	0.7008	0.6681	0.5971	0.5964	0.5762	0.5974	0.5704	0.5666	0.5159
29	Plastic fabricated products	0.7793	0.8066	0.7614	0.7319	0.6893	0.6649	0.6729	0.6852	0.6780	0.6155
30	Leather and leather products	0.4269	0.4045	0.3947	0.3687	0.3819	0.3514	0.3566	0.3606	0.3379	0.3135
31	Yarns and man made fibres	0.7337	0.7309	0.6767	0.6611	0.6009	0.5680	0.5892	0.6456	0.6226	0.6067
32	Fabrics	0.7245	0.7208	0.6537	0.6315	0.5754	0.5411	0.5600	0.6164	0.6076	0.5929
33	Other textile products	0.7281	0.7294	0.6609	0.6392	0.5859	0.5515	0.5717	0.6232	0.6146	0.5932
34	Hosiery and knitted wear	0.3097	0.3023	0.2990	0.2763	0.2604	0.2564	0.2558	0.2790	0.2609	0.2552
35	Clothing and accessories	0.3209	0.3126	0.3123	0.2884	0.2702	0.2662	0.2659	0.2908	0.2732	0.2641
36	Lumber and timber	0.7329	0.7067	0.6691	0.6260	0.6276	0.6323	0.6413	0.6304	0.6350	0.5945
37	Veneer and plywood	0.7217	0.6994	0.6601	0.6210	0.6236	0.6254	0.6333	0.6250	0.6234	0.5922
38	Other wood fabricated materials	0.7192	0.7060	0.6630	0.6233	0.6264	0.6316	0.6399	0.6273	0.6252	0.5941
39	Furniture and fixtures	0.4865	0.5134	0.4940	0.4642	0.4503	0.4437	0.4742	0.5044	0.5080	0.4552
40	Pulp	1.5599	1.3444	1.3915	1.3269	1.2833	1.2213	1.1893	1.2302	1.3532	1.4123
41	Newsprint and other paper stock	1.5563	1.3433	1.3873	1.3228	1.2796	1.2190	1.1873	1.2268	1.3488	1.4076
42	Paper products	1.3652	1.1851	1.2077	1.1647	1.1315	1.0896	1.0603	1.0825	1.1699	1.1965
43	Printing and publishing	0.4618	0.4330	0.4322	0.4184	0.4143	0.4096	0.4202	0.4465	0.4585	0.4355
44	Advertising and print media	0.4421	0.4187	0.4193	0.4069	0.4050	0.4034	0.4144	0.4372	0.4496	0.4261
45	Iron and steel products	2.0116	1.9941	1.9673	1.9272	1.8795	1.9219	1.8827	1.8100	1.7732	1.5551
46	Aluminum products	2.0765	2.0730	2.0669	2.0184	1.9730	2.0240	1.9813	1.9322	1.9088	1.6274
47	Copper and copper alloy products	2.0707	2.0543	2.0572	2.0062	1.9622	2.0103	1.9707	1.9336	1.9087	1.6143
48	Nickel products	2.1019	2.0725	2.0885	2.0377	1.9919	2.0395	2.0027	1.9482	1.9284	1.6521
49	Other non ferrous metal products	1.8783	1.9141	1.9351	1.8746	1.8528	1.8734	1.8360	1.7677	1.7157	1.5230
50	Boilers, tanks and plates	0.7161	0.6974	0.7331	0.7209	0.6900	0.6896	0.7243	0.7176	0.6891	0.5772
51	Fabricated structural metal products	0.9525	0.8730	0.9506	0.9651	0.9278	0.9144	0.9255	0.8918	0.8519	0.7139
52	Other metal fabricated products	0.7857	0.7751	0.8088	0.8005	0.7413	0.7629	0.8037	0.8187	0.7965	0.6693
53	Agricultural machinery	0.4509	0.4924	0.4733	0.4267	0.4225	0.4068	0.4352	0.4262	0.4231	0.3744
54	Other industrial machinery	0.5864	0.5965	0.5752	0.5538	0.5415	0.5210	0.5217	0.4756	0.4588	0.3909
55	Motor vehicles	0.3443	0.3320	0.3349	0.3254	0.3234	0.3170	0.3356	0.3135	0.3147	0.2622
56	Motor vehicle parts	0.3797	0.3797	0.3703	0.3422	0.3358	0.3330	0.3527	0.3337	0.3340	0.2811
57	Other transport equipment	0.4404	0.4230	0.4675	0.4281	0.4225	0.4107	0.4372	0.4030	0.4073	0.3492
58	Household appliances and receivers	0.5053	0.4758	0.4699	0.4686	0.4309	0.4439	0.4235	0.3776	0.3478	0.2950
59	Other electrical products	0.4824	0.4494	0.4378	0.4461	0.4043	0.4263	0.3993	0.3552	0.3187	0.2636
60	Cement and concrete products	2.8748	2.9433	2.6338	2.5744	2.4735	2.5769	2.7137	2.8027	2.8505	2.7705
61	Other non-metallic mineral products	2.7039	2.7472	2.4826	2.3878	2.2600	2.4207	2.5118	2.6189	2.6455	2.5378

Table 8.3

Carbon Dioxide Intensity of Commodity Production, 1981-1990 (Concluded)

	Commodity	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		tonnes per thousand 1986 dollars									
62	Gasoline and fuel oil	1.8917	2.0285	2.0326	2.1526	2.1923	2.2690	2.4746	2.3925	2.4431	2.3646
63	Other petroleum and coal products	1.7981	1.9229	1.9022	1.9799	1.9827	2.0478	2.2019	2.1448	2.1855	2.1131
64	Industrial chemicals	1.8109	1.9324	1.8698	1.8814	1.8065	1.6484	1.6601	1.6920	1.5650	1.4618
65	Fertilizers	1.3141	1.1938	1.3270	1.1327	1.1558	1.1383	1.1773	1.2814	1.3127	1.1753
66	Pharmaceuticals	1.8257	1.9527	1.8865	1.8921	1.8079	1.6420	1.6565	1.7127	1.5785	1.4707
67	Other chemical products	1.7669	1.8767	1.8277	1.8237	1.7447	1.5976	1.6111	1.6548	1.5301	1.4240
68	Scientific equipment	0.5011	0.4783	0.4776	0.4586	0.4526	0.4527	0.4408	0.4220	0.4103	0.3743
69	Other manufactured products	0.6049	0.5952	0.5940	0.5853	0.5958	0.6048	0.6173	0.6312	0.6393	0.5774
70-72	Construction	0.5901	0.5436	0.5179	0.5325	0.5373	0.5167	0.5379	0.5311	0.5165	0.4591
73	Pipeline transportation	1.9041	1.8054	1.3008	1.5751	1.9082	1.7873	1.9345	2.2071	2.3779	2.2435
74	Transportation and storage	1.5603	1.4595	1.4522	1.3872	1.4420	1.4122	1.3726	1.4620	1.4945	1.4137
75-77	Radio, television, telephone and postal services	0.2155	0.2161	0.1981	0.2025	0.2086	0.1950	0.1853	0.1834	0.1685	0.1483
78	Electric power	4.5548	5.0424	4.7581	4.8571	4.6837	4.2801	4.6488	4.9916	5.4810	4.9464
79	Other utilities	4.5611	5.0397	4.7541	4.8526	4.6821	4.2803	4.6482	4.9914	5.4795	4.9468
80	Wholesale margins	0.5547	0.5531	0.5122	0.5168	0.4941	0.4599	0.4495	0.4511	0.4368	0.4220
81	Retail margins	0.4987	0.5050	0.4675	0.4695	0.4589	0.4365	0.4304	0.4381	0.4352	0.4339
82	Imputed rent, owner occupied dwellings	0.0379	0.0358	0.0323	0.0342	0.0339	0.0334	0.0362	0.0357	0.0335	0.0282
83	Other finance, insurance and real estate	0.3749	0.4274	0.4149	0.3905	0.3972	0.3905	0.3699	0.3736	0.3771	0.3893
84	Business services	0.2233	0.2214	0.2155	0.2025	0.2125	0.2100	0.1903	0.1865	0.1798	0.1789
85	Education services	0.4757	0.4632	0.4289	0.4697	0.4928	0.4552	0.4940	0.5097	0.5434	0.5235
86	Health services	0.2274	0.2303	0.2042	0.2178	0.2114	0.2062	0.2184	0.2074	0.2008	0.1962
87	Amusement and recreation services	0.3355	0.3447	0.3253	0.3110	0.3109	0.3047	0.2910	0.3047	0.3214	0.3285
88	Accommodation and food services	0.5117	0.5201	0.5126	0.5082	0.5107	0.4824	0.4551	0.4699	0.4848	0.4687
89	Other personal and miscellaneous services	0.4991	0.5010	0.4731	0.4720	0.4665	0.4567	0.4413	0.4354	0.4311	0.4236
90	Transportation margins	1.5150	1.4022	1.3906	1.3391	1.4006	1.3685	1.3249	1.4160	1.4492	1.3701
91	Operating, office, laboratory and food supplies	0.5438	0.5341	0.5265	0.5031	0.4723	0.4429	0.4449	0.4389	0.4156	0.4017
92	Travel, advertising and promotion	0.9492	0.8904	0.8595	0.8587	0.8365	0.8164	0.7311	0.7337	0.6264	0.6994

Source:
Statistics Canada, National Accounts and Environment Division.

en process can be altered within certain limits to use more or less energy to produce a given commodity. Replacing humans with robots on an automobile assembly line will change the quantity of energy consumed (and carbon dioxide released) per car produced, for example.

Not only does the absolute quantity of fuel consumed influence the carbon dioxide intensity of production but, as discussed above, so does the composition of this consumption. Thus, the declining carbon dioxide intensity of some commodities' production seen in Table 8.3 is due to switches from refined petroleum products to natural gas during the early 1980s when oil prices were very high. It is worth noting that price effects such as this will tend to shift the composition of fuel consumption toward the least-cost mixture, which is not always the least-carbon dioxide intensive mixture. It just so happened that the price of crude oil was high relative to that of natural gas during the first half of the 1980s, and, since natural gas produces less carbon dioxide per unit of energy than petroleum products, businesses shifted toward a less carbon dioxide intensive mix of energy commodities. If the reverse had been true with respect to relative energy prices, then businesses would have just as quickly moved toward a more carbon dioxide intensive mix of commodities.

It is not possible here to discuss the trends in carbon dioxide intensity for each commodity listed in Table 8.3. Much can be learned, however, from looking in detail at the data for some important semi-processed commodities that are used as inputs into a large number of finished goods. These include agricultural products (commodities 1-3 in Table 8.3), fossil fuels (9-11), wood products (36-38), pulp and paper (40-41), primary metals (45-49), cement and concrete (60), petroleum products (62-63), and electric power (78).

The carbon dioxide intensity of agricultural products moved downward from 1981 until 1986, after which it increased until 1989; a slight decrease in intensity occurred in 1990. This same pattern was seen in the production of cement and concrete, pulp and paper, and electricity. The increase in carbon dioxide intensity for these commodities subsequent to 1986 is explained by the fact that their producers stopped switching away from petroleum products after the fall in oil prices in 1986, while increasing their total consumption of fossil fuels rapidly at the same time (Statistics Canada, 1992). This resulted in an increase in the carbon dioxide intensities of production for these commodities from 1986 to 1989, although not to the levels reached in the early 1980s.

The carbon dioxide intensity of crude oil and natural gas production increased significantly over the period, due largely to increased consumption of natural gas by the

Table 8.4
Energy Intensity of Commodity Production, 1981-1990

	Commodity	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		gigajoules per thousand 1986 dollars									
1,2	Grains and live animals	18.0631	17.2113	21.2099	16.6118	16.9643	16.1801	16.5575	17.8408	18.6188	16.8603
3	Other agricultural products	18.0172	17.1799	21.1150	16.5741	16.9287	16.1684	16.4660	17.6425	18.3805	16.7204
4	Forestry products	13.4421	11.9596	11.4366	10.6177	11.5760	12.8501	11.7228	11.4594	10.8897	12.3070
5	Fish landings	18.5033	18.3388	16.8957	19.0715	15.7429	15.3098	15.3828	15.2289	15.6470	14.9649
6	Hunting and trapping products	18.5137	18.3388	16.8954	19.0715	15.7429	15.3098	15.3829	15.2208	15.6462	14.9658
7	Iron ores and concentrates	26.3168	24.2631	25.5969	22.6160	22.1662	22.6302	22.3403	23.5191	23.5105	21.2346
8	Other metal ores and concentrates	27.4283	26.5840	27.3973	23.8890	23.9769	24.4272	24.6061	24.5562	24.3151	22.5179
9	Coal	26.2875	24.2250	25.5685	22.5847	22.1680	22.6313	22.3411	23.5213	23.4507	21.2424
10	Crude mineral oils	22.4778	25.4941	25.6377	26.4715	25.4406	29.2639	31.1218	29.6138	31.9300	30.7748
11	Natural gas	22.4822	25.5556	25.7203	26.5565	25.5416	29.3084	31.1126	29.6051	31.9157	30.7606
12	Non-metallic minerals	21.8210	23.1931	22.5055	21.3979	20.3739	21.4785	22.3253	23.0472	23.3987	20.9424
13	Services incidental to mining	15.8470	15.7434	15.2458	14.7603	14.1581	14.1820	15.6928	16.9373	15.7922	13.6203
14	Meat products	13.4580	13.1245	14.4608	12.5968	12.4000	12.3493	12.7447	13.0991	13.4442	12.5220
15	Dairy products	13.5138	13.1008	14.4967	12.6028	12.3616	12.3767	12.7779	13.1359	13.4899	12.5574
16	Fish products	13.5295	13.1190	14.5185	12.6325	12.3799	12.3943	12.7991	13.1555	13.5104	12.5786
17	Fruit and vegetable preparations	13.4321	13.0372	14.3644	12.5089	12.2560	12.2519	12.6469	13.0129	13.3110	12.3946
18	Feeds	13.5318	13.1759	14.4419	12.5639	12.2975	12.2754	12.6083	12.9516	13.3258	12.3654
19	Flour, wheat, meal and other cereals	13.5102	13.0919	14.5015	12.6062	12.3656	12.3816	12.7832	13.1396	13.5024	12.5679
20	Breakfast cereal and bakery products	13.2361	12.7735	13.9768	12.2410	12.0742	12.0608	12.3606	12.6012	12.9111	12.0800
21	Sugar	13.5102	13.0919	14.5017	12.6062	12.3656	12.3816	12.7832	13.1458	13.4978	12.5624
22	Miscellaneous food products	13.4811	13.0566	14.3865	12.5235	12.3182	12.2815	12.6513	13.0548	13.4251	12.4993
23	Soft drinks	10.9299	10.8933	10.9436	10.3795	10.0440	10.2179	10.1574	9.9678	9.6822	9.2952
24	Alcoholic beverages	10.9247	10.8795	10.9314	10.3736	10.0381	10.2137	10.1504	9.8514	9.5349	9.1653
25,26	Tobacco, and cigarettes	8.8911	8.3327	9.2963	8.7618	7.9733	8.7921	7.3506	7.4329	8.1960	8.1692
27	Tires and tubes	12.9877	11.9270	12.7864	11.4752	10.5625	10.8183	11.2496	10.4724	10.3932	9.5176
28	Other rubber products	12.3649	11.8206	11.9552	10.6387	10.2867	10.2224	10.8163	10.2520	10.2388	9.4730
29	Plastic fabricated products	13.2544	13.4939	13.3700	12.4610	11.5759	11.4790	11.8984	11.8681	12.0547	10.9985
30	Leather and leather products	7.5727	7.1938	7.3533	6.8245	6.8954	6.4616	6.6062	6.6754	6.2159	5.8166
31	Yarns and man made fibres	13.3809	13.3593	12.8223	12.5718	11.0555	10.5328	11.0229	12.0067	11.6232	11.5040
32	Fabrics	13.2476	13.1778	12.5118	12.2618	10.7521	10.2044	10.6501	11.6637	11.4300	11.3698
33	Other textile products	13.2455	13.2563	12.5745	12.2775	10.8360	10.3127	10.7775	11.6881	11.4865	11.2811
34	Hosiery and knitted wear	5.6641	5.5685	5.7073	5.3166	4.9343	4.8780	4.9261	5.2907	4.9047	4.9260
35	Clothing and accessories	5.8673	5.7431	5.9516	5.5333	5.0994	5.0527	5.1084	5.4956	5.1208	5.0824
36	Lumber and timber	13.2235	13.0563	12.6651	11.8825	11.3816	11.3914	12.4584	12.0836	11.9596	10.7384
37	Veneer and plywood	12.9669	12.8991	12.3781	11.7252	11.2455	11.1476	12.2281	11.9264	11.7010	10.6954
38	Other wood fabricated materials	12.8861	12.9203	12.3729	11.6913	11.2099	11.1778	12.2024	11.8762	11.6568	10.7047
39	Furniture and fixtures	8.7861	9.4230	9.3671	8.5884	8.2470	8.0374	8.8382	9.4165	9.4048	8.7274
40	Pulp	32.5132	26.8978	34.8291	31.0289	30.1581	29.1764	27.5529	27.8303	28.8233	31.5137
41	Newsprint and other paper stock	32.3935	26.8310	34.6939	30.9184	30.0560	29.1110	27.4987	27.7412	28.7211	31.3981
42	Paper products	27.9489	23.3165	29.2933	26.5315	25.8673	25.3601	23.9650	23.8806	24.5149	26.2334
43	Printing and publishing	9.0055	8.2027	9.4986	8.7312	8.5938	8.6053	8.7674	9.1417	9.1263	9.0247
44	Advertising and print media	8.5925	7.9116	9.1644	8.4677	8.3754	8.4593	8.6353	8.9242	8.9322	8.8115
45	Iron and steel products	36.7927	37.5993	36.8900	33.5633	33.3517	32.3160	33.4957	32.2640	31.2872	31.4067
46	Aluminum products	37.9993	39.1129	38.7874	35.1514	35.0673	34.0691	35.2883	34.4358	33.6655	32.9149
47	Copper and copper alloy products	37.8707	38.7392	38.5701	34.9081	34.8124	33.7705	35.0477	34.4653	33.6631	32.6452
48	Nickel products	38.4483	39.0772	39.1563	35.4557	35.3383	34.2664	35.6194	34.7225	34.0063	33.4235
49	Other non ferrous metal products	34.0125	35.6710	35.9430	32.3368	32.6096	31.3030	32.3886	31.1749	29.8541	30.0880
50	Boilers, tanks and plates	13.1670	13.1589	13.9516	13.2652	12.5925	12.1944	13.2378	13.1146	12.5036	11.3227
51	Fabricated structural metal products	17.1510	15.9795	17.4210	16.8269	16.0718	15.2932	16.1892	15.9456	15.2096	13.8997
52	Other metal fabricated products	14.3384	14.4838	15.2497	14.4532	13.3667	13.2399	14.5055	14.8095	14.3312	13.1372
53	Agricultural machinery	8.2499	9.2986	9.0485	7.9069	7.7527	7.2397	8.0548	7.8383	7.7085	7.2907
54	Other industrial machinery	10.6671	11.1612	10.9204	10.0242	9.8280	9.1369	9.4342	8.6217	8.2722	7.5003
55	Motor vehicles	6.1228	6.0684	6.1983	5.8134	5.6514	5.4904	6.0690	5.6178	5.5979	4.9348
56	Motor vehicle parts	6.7511	6.9522	6.8562	6.1083	5.8751	5.7472	6.3713	5.9841	5.9492	5.3076
57	Other transport equipment	7.5020	7.3923	8.1589	7.3780	7.0880	6.8395	7.5126	6.8870	6.8969	6.1707
58	Household appliances and receivers	8.6617	8.7113	8.5002	7.6136	7.4568	7.0181	7.2818	6.5950	6.0750	5.4570
59	Other electrical products	8.2275	8.2250	7.9103	7.1521	6.9585	6.6127	6.7669	6.1582	5.5395	4.8722
60	Cement and concrete products	30.4005	31.0541	28.9025	28.2347	24.9045	25.8912	27.5896	28.7569	28.9673	27.1460
61	Other non-metallic mineral products	29.1256	29.6459	27.7238	26.6299	23.2462	24.6418	25.9226	27.1521	27.1229	25.1511

Table 8.4

Energy Intensity of Commodity Production, 1981-1990 (Concluded)

	Commodity	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		gigajoules per thousand 1986 dollars									
62	Gasoline and fuel oil	28.0024	31.1210	31.8874	34.1154	33.5294	34.9465	38.4017	36.6338	37.8890	36.3380
63	Other petroleum and coal products	26.9434	29.5680	30.0617	31.1230	30.1698	31.7415	34.7341	33.3962	34.4610	32.9507
64	Industrial chemicals	25.9090	27.1812	27.3452	25.3588	24.1900	23.3039	24.0676	23.8442	23.7726	21.1792
65	Fertilizers	23.2300	21.4343	23.9571	20.8442	20.5012	19.8212	19.7958	21.2815	22.3104	20.1672
66	Pharmaceuticals	25.8679	27.1461	27.2544	25.1044	23.8345	22.9845	23.8056	23.8850	23.8068	20.9955
67	Other chemical products	25.0894	26.2099	26.4960	24.3412	23.0957	22.4186	23.1844	23.1777	23.0663	20.3645
68	Scientific equipment	8.9223	8.6455	8.9126	8.2568	8.0036	7.9324	7.9995	7.5997	7.3444	7.0027
69	Other manufactured products	10.5471	10.6928	11.0773	10.5853	10.5228	10.5638	10.9977	11.0181	11.1473	10.4074
70-72	Construction	8.9946	8.4105	8.2408	8.3571	8.1576	7.7036	8.1772	8.0527	7.7798	7.0171
73	Pipeline transportation	39.1705	36.6325	26.6888	32.5636	38.0046	35.0871	38.3954	42.9730	44.9944	43.2699
74	Transportation and storage	23.5228	22.3525	22.6480	21.7632	21.7303	21.1976	20.7311	21.8939	22.1807	21.2832
75-77	Radio, television, telephone and postal services	3.6923	3.7962	3.5209	3.6088	3.6133	3.3660	3.2555	3.2292	2.9656	2.6388
78	Electric power	62.7527	69.2618	66.4360	66.9626	62.2955	56.8966	60.7683	65.2628	72.4596	65.1867
79	Other utilities	62.8224	69.2260	66.3978	66.9098	62.2761	56.8960	60.7606	65.2493	72.4338	65.1777
80	Wholesale margins	9.0563	9.1986	8.7406	8.6865	8.1208	7.5662	7.4346	7.4300	7.1850	6.9832
81	Retail margins	9.1843	9.5542	8.9322	9.0654	8.7323	8.3260	8.2797	8.4220	8.2971	8.2696
82	Imputed rent, owner occupied dwellings	0.5914	0.5703	0.5288	0.5532	0.5308	0.5210	0.5731	0.5641	0.5278	0.4513
83	Other finance, insurance and real estate	7.0150	8.1740	7.9425	7.5762	7.5652	7.3663	7.1496	7.2413	7.1894	7.3550
84	Business services	3.7259	3.7525	3.7286	3.5248	3.6383	3.5709	3.3133	3.2507	3.1213	3.1201
85	Education services	8.9739	9.0584	8.3967	9.2885	9.5723	8.8914	9.6658	10.0867	10.6060	10.1595
86	Health services	3.7705	3.8617	3.5179	3.7579	3.5568	3.4715	3.7463	3.6177	3.4932	3.4021
87	Amusement and recreation services	6.4601	6.8029	6.4921	6.2623	6.1298	5.9885	5.9318	6.2097	6.5219	6.6183
88	Accommodation and food services	9.3554	9.7119	9.7313	9.8114	9.6612	9.1919	8.7894	9.0125	9.1577	8.8399
89	Other personal and miscellaneous services	8.4558	8.6737	8.3105	8.3091	8.0305	7.8373	7.7091	7.6176	7.4730	7.3172
90	Transportation margins	22.8394	21.4750	21.6860	21.0080	21.1065	20.5411	20.0109	21.2056	21.5087	20.6262
91	Operating, office, laboratory and food supplies	9.1934	8.9572	9.3529	8.6748	8.0766	7.6180	7.7516	7.6029	7.2375	7.1451
92	Travel, advertising and promotion	15.1523	14.3779	14.4023	14.3767	13.5518	13.2157	11.9787	11.9426	9.9739	11.4172

Source:
Statistics Canada, National Accounts and Environment Division.

crude petroleum and natural gas industry.[1] This increase was in turn a result of the nearly 69 percent increase in natural gas production that occurred during the 1980s.

Wood products experienced a decline in carbon dioxide intensity over the period in question. This was a result both of a shift away from petroleum products toward natural gas by the wood products industry and an overall decline in the energy intensiveness of wood products (Table 8.4).

The carbon dioxide intensities of the primary metal products fell steadily from 1981 to 1990. The same result was seen for the energy intensities of these commodities (Table 8.4), although the declines in carbon dioxide intensities were greater than those for the energy intensities (21 percent on average versus 14 percent on average respectively from 1981 to 1990). Part of the reduction in carbon dioxide intensity for these commodities was the result of the overall reduction in their energy intensity seen in Table 8.4; the remainder was due to shifts in the composition of energy consumption by this industry toward a less carbon dioxide intensive mix.

1. Natural gas consumption by this industry includes gas that is flared in the field and at processing plants, gas used for energy purposes in the gathering system and at processing plants, and gas otherwise used in the production processes of this industry.

Carbon dioxide intensity of final consumption

Since the production of goods and services takes place to meet demand for final consumption, it is reasonable to ask what portion of industrial carbon dioxide emissions are attributable to the production required to meet the demand from different final consumption categories.[2] Table 8.5 shows such a breakdown of industrial carbon dioxide emissions.[3] The first line in Table 8.5, for example, presents the carbon dioxide emissions from the business sector that are due to the production of commodities to meet the demand from households and non-profit organisations (personal consumption). Given that personal consumption makes up the largest category of final consumption, it is not surprising to see that it was responsible for the greatest portion of industrial carbon dioxide emissions in each year between 1981 and 1990.

2. Final consumption includes the current expenditures of households, governments and non-profit institutions, as well as investment in fixed capital formation, additions to inventories of goods, and exports.
3. It must be emphasized that the figures shown in Table 8.5 are the emissions associated with the production activity required to meet the demand for commodities from final consumption categories. They do not represent the emissions associated with the consumption of these commodities once they have been purchased. The latter were shown in Table 8.1 under household and government headings.

Table 8.5
Industrial Carbon Dioxide Emissions by Final Demand Category, 1981-1990

Final demand category	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	kilotonnes									
Personal expenditure	122 525	122 774	122 945	124 460	129 477	132 494	138 505	150 086	156 781	151 059
Government current expenditure	21 089	21 859	21 292	21 120	21 932	22 308	23 560	25 340	26 217	25 130
Fixed capital formation	50 656	43 509	40 001	40 726	44 014	42 594	47 993	50 565	51 553	45 132
Exports	108 449	98 057	103 956	115 394	121 682	114 717	124 620	130 639	139 906	125 062
Other	5 602	2 117	3 063	4 562	3 339	3 695	3 912	6 908	5 905	7 738
Total business sector emissions	**308 320**	**288 317**	**291 255**	**306 263**	**320 444**	**315 808**	**338 586**	**363 538**	**380 360**	**354 123**
Imports	79 308	63 693	67 180	76 856	81 626	83 581	91 430	103 718	116 406	99 021

Source:
Statistics Canada, National Accounts and Environment Division.

Some explanation is required for the row labelled "imports" in Table 8.5. The emissions reported in this row are not the actual emissions that occurred in other countries during the production of Canada's imported commodities. Rather, they represent the emissions that would have occurred in Canada had we produced domestically this group of commodities. The assumption implicit in these estimates is that foreign industries emit the same quantity of carbon dioxide in producing one unit of a particular commodity as do Canadian industries.[1] The results reported in Table 8.5 indicate that Canada exported a more carbon dioxide intensive set of goods and services than it imported in all years considered in this study.

Table 8.6 reports the same data as Table 8.5, but per unit of expenditure rather than in absolute terms. When considered from this perspective, the export category of final consumption was the most carbon dioxide intensive in all years. This means that we emitted more carbon dioxide in producing one dollar's worth of our exports than was the case for any other category of final demand. Over the period considered, there were steady declines in the carbon dioxide intensity of all categories of final demand, from 6 percent for government current expenditure to nearly 27 percent for fixed capital formation. There are a number of possible reasons for this decline, several of which have been discussed above with respect to the carbon dioxide intensity of production activity. Aside from the reasons mentioned above, the carbon dioxide intensity of expenditure can also fall as a result of shifts in expenditure away from commodities that are relatively carbon dioxide intensive toward those that are less so. Another phenomenon that is certain to have contributed to the declines shown in Table 8.6 was the increase between 1981 and 1990 in the percentage of our domestic consumption met by imported goods and services. During this period imports rose steadily from 23.6 percent to 30.3 percent of domestic consumption. Since the production of our imported goods does not result in any domestic carbon dioxide emissions, increasing import levels led to declining carbon dioxide intensity of domestic consumption.

1. This assumption is reasonable given that most Canadian external trade is with the United States where the technological structure is very similar to that in Canada.

Conclusion

The data presented in this chapter indicate that the carbon dioxide emissions are closely tied to the overall level of economic activity (as measured by GDP) and are substantially affected by the prices of energy commodities. While petroleum prices were high during the first half of the 1980s, the carbon dioxide intensiveness of the business sector overall, as well as that of many individual commodities, declined significantly. With the fall of oil prices in 1986, carbon dioxide intensities began to rise again for the business sector, and for many commodities, although they did not regain the

Table 8.6
Carbon Dioxide Intensity of Final Demand, 1981-1990

Final demand category	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	kilotonnes									
Personal expenditure	0.5079	0.5038	0.4848	0.4694	0.4653	0.4454	0.4453	0.4620	0.4657	0.4447
Government current expenditure	0.2081	0.2108	0.2031	0.1988	0.2001	0.1976	0.2044	0.2109	0.2113	0.1965
Fixed capital formation	0.4911	0.4792	0.4469	0.4487	0.4435	0.4194	0.4261	0.4075	0.3926	0.3564
Exports	1.0238	0.9536	0.9506	0.8964	0.8932	0.8544	0.8942	0.8656	0.9228	0.8095
Other	0.6212	0.4074	0.5209	0.4453	0.3480	0.3511	0.4342	0.5420	0.4964	0.5234
Imports	0.7422	0.7015	0.6843	0.6739	0.6659	0.6267	0.6410	0.6375	0.6828	0.5668

Source:
Statistics Canada, National Accounts and Environment Division.

levels seen in the early 1980s. The latter point means that the Canadian economy became more efficient in its use of the environment to absorb carbon dioxide emissions over the decade of the 1980s. However, the fact that there was an upward trend in intensiveness in the late 1980s suggests that some of these efficiency gains may have been temporary. Future energy consumption and carbon dioxide emission data developed at Statistics Canada will make it possible to determine if this was the case.

References

Government of Canada, 1991, ***The State of Canada's Environment***, Ottawa.

Hamilton, Kirk, 1993, "Energy Consumption" in ***Environmental Perspectives 1993: Studies and Statistics***, Statistics Canada Cat. No. 11-528E, Ottawa.

Houghton, J. T., G. J. Jenkins and J. J. Ephraums, 1990, ***Climate Change: The IPCC Assessment***, Cambridge University Press, Cambridge.

International Energy Agency, 1991, ***Greenhouse Gas Emissions: The Energy Dimension***, International Energy Agency/Organisation for Economic Cooperation and Development, Paris.

Jaques, A. P., 1992, ***Canada's Greenhouse Gas Emissions: Estimates for 1990***, Environment Canada Report EPS 5/AP/4, Minister of Supply and Services, Ottawa.

Smith, Robert, 1993, "Canadian Greenhouse Gas Emissions: An Input-Output Study" in ***Environmental Perspectives 1993: Studies and Statistics***, Statistics Canada Cat. No. 11-528E, Ottawa.

Statistics Canada, 1992, ***Energy Statistics Handbook***, Cat. No. 57-601, Ottawa.

9 Government Expenditures on Environmental Protection

by Anik Lacroix

Introduction

In the four years since the Green Plan[1] was launched by the Government of Canada in 1991, Statistics Canada has been involved in developing a system of environmental and natural resource accounts[2] that will be satellite components of the Canadian System of National Accounts. One of these accounts is aimed at highlighting the costs related specifically to environmental protection for each economic sector; governments, businesses and households.

This chapter presents the results of the first detailed analysis of environmental protection expenditures by federal, provincial/territorial and local governments during the 1965-1994 period. Such expenditures include, on the one hand, those aimed specifically at preventing or reducing the emission of wastes and pollutants generated by economic activity (pollution abatement and control expenditures (PAC)) and, on the other, expenditures aimed at protecting land (e.g. expenditures for parks), sub-soil resources, forests, water resources, fauna and fish.

The classification system of public government expenditures in Canada does not permit a breakdown between natural resource conservation activities and those aimed at developing the resources. As a result available conservation expenditure data relate to both natural resource conservation and development. Also, at the time of writing, park expenditure data were only available for provincial/territorial governments. Federal government data on park expenditures exist but have not been reconciled with the conceptual framework of environmental protection expenditures. Therefore, these limitations should be borne in mind when interpreting the results. The data presented in this article are collected by Statistics Canada from administrative sources and from surveys. The appendix provides a list of concepts used and a description of existing data.

1. The Canadian Green Plan is a government initiative over many years that comprises a number of actions aimed at protecting health and the environment, ensuring sustainable development of forestry, agricultural, fishing and water resources, and at protecting wildlife and its habitat, as well as providing comprehensive statistics on the environment in Canada.
2. This system of satellite accounts will consist of a Natural Resource Stock Account, a Natural Resource Use Account, a Waste Output Account and an Environmental Protection Expenditure Account.

Consolidated government expenditures on environmental protection[3]

In fiscal year 1991/92[4], consolidated capital and current expenditures of federal, provincial/territorial and local governments on environmental protection were estimated at $18 billion or 3 percent of gross domestic product (GDP), compared with $15 billion in 1988[5] (2.5 percent of GDP). From this total, $4.75 billion were spent to finance PAC activities in 1991; $13.3 billion were spent to finance natural resource conservation and development activities (see Table 9.2). These figures exclude expenditures for parks.

Government investment in pollution abatement and control, 1985-1992

Of all government capital expenditures on environmental protection and resource development made in 1992 (calendar year), $1.4 billion or 11 percent were in PAC activities, waste disposal facilities, sewage systems and sanitation equipment, according to the results of the Capital and Repair Expenditure Survey. These results are summarized in Table 9.1 (see the Appendix for a list of the categories). Between 1985 and 1992 investment in environmental protection increased at an average annual rate of 6 percent, which is more than double that of all government investment combined. Eighty-five percent of the investment related to PAC in 1992 was made by local governments and was for the installation of sewage systems. Investment in sewage system construction represented almost 9 percent of total government investment in 1992. In comparison, investment in waste disposal facilities accounted for close to one percent of total government investment between 1986 and 1992.

3. These expenditures exclude transfer payments between governments *for pollution abatement and control (PAC) and natural resource conservation and development.*
4. Unless otherwise indicated, years referred to here are fiscal years.
5. Data on consolidated expenditures for PAC and natural resource conservation and development are only available for 1988-1991 fiscal years. Historical data exist at the consolidated level however they include water supply expenditures, tourism, trade and industrial development expenditures as well as expenditures for water power. See Appendix.

Table 9.1

Consolidated Capital and Repair Expenditures by Governments on Environmental Protection, 1985-1992 (Calendar Year)

	1985[1]	1986	1987	1988	1989	1990	1991	1992
	thousand dollars							
Pollution abatement & control - Construction	x	40 182	26 901	42 973	68 175	134 261	137 514	141 792
Waste disposal facilities	x	81 457	85 217	90 698	96 439	134 026	100 638	140 543
Sewage systems								
Sewage treatment & disposal plants	666 098	240 154	431 732	378 508	587 117	668 391	555 576	530 034
Sanitary & storm sewers	302 567	676 466	520 995	627 583	560 745	721 959	564 282	578 313
Other sewage system construction[2]	4 369	6 180	12 228	11 049	25 363	7 116	12 840	3 277
Total sewage system construction	973 034	922 800	964 955	1 017 140	1 173 225	1 397 466	1 132 698	1 111 624
Pollution abatement & control equipment	5 728	x	x	x	x	x	43 680	23 408
Sanitation equipment[3]	1 817	19 882	15 694	15 925	27 964	61 210	5 286	7 928
Total government investment in environmental protection	**999 903**	**1 064 321**	**1 092 767**	**1 166 736**	**1 365 803**	**1 726 963**	**1 419 816**	**1 425 295**
Federal government	29 501	40 819	54 424	48 902	61 867	55 288	72 307	99 782
Provincial governments	67 331	56 715	32 213	45 094	38 700	60 314	60 723	79 239
Local governments	903 071	966 787	1 006 130	1 072 740	1 265 236	1 611 361	1 286 786	1 246 274
Total government investment in environmental protection	**999 903**	**1 064 321**	**1 092 767**	**1 166 736**	**1 365 803**	**1 726 963**	**1 419 816**	**1 425 295**
	As a percentage of total government investment							
Total government investment in environmental protection	9	10	11	10	11	12	11	11

Notes:
1. In 1985 local government expenditures for machinery and equipment were excluded.
2. Also includes investment in lagoon construction; in 1992 data on investments in lagoons and other sewage construction were available separately (respectively $2,905,000 and $372,000).
3. Combined PAC equipment and sanitation equipment expenditures from 1986 to 1990, because of confidentiality.

Sources:
Statistics Canada, Investment and Capital Stock Division and Public Institutions Division (local government expenditures).

Consolidated provincial/territorial and local government expenditures in 1991[1]

Consolidated capital and current expenditures by provincial/territorial and local governments related to PAC, natural resource conservation and development and the development of parks were $12.6 billion in 1991 and accounted for 6 percent of total consolidated expenditures by these governments in Canada[2].

Pollution abatement and control expenditures[3]

As shown in Table 9.2 consolidated expenditures of provincial/territorial and local governments on PAC, the bulk of government expenditures on PAC in Canada, were $4 billion in 1991; this represented 2 percent of total consolidated expenditures of the two levels of government. The main targets were sewage disposal (48 percent of PAC expenditures) and waste treatment (32.5 percent of PAC expenditures). However, expenditures on sewage treatment declined significantly in importance since 1988 when they accounted for more than half of PAC expenditures, in favour of expenditures on other environmental services.

1. Includes consolidated provincial/territorial government expenditures for parks.
2. Total consolidated government expenditure data are available through the Public Institutions Division and in Statistics Canada, ***Public Finance, Historical Data 1965/66-1991/92 Financial Management System***, Cat. No. 68-512, May 1992.
3. These are expenditures earmarked for the following activities: sewage treatment, waste treatment, other activities to abate and control air, soil and groundwater pollution (pollution control category) and other environmental services such as administration of an environment department. See Appendix for more detail.

Natural resource conservation and development expenditures[4] and expenditures for parks

Consolidated capital and current expenditures for natural resource conservation and development represented 4 percent of total consolidated expenditures by provincial/territorial and local governments in 1991, twice as much as PAC expenditures. Development and conservation of agriculture consumed $4.2 billion or 50 percent of the expenditures allocated for resource conservation and development. The development and conservation of forests and mines and other activities such as energy conservation or management of Crown land, accounted for expenditures of over $1 billion each. Expenditures on game and fish accounted for approximately $300 million. In Newfoundland and the Northwest Territories, most conservation and development expenditures were on mines, oil and gas, while in British Columbia and Nova Scotia forestry expenditures were dominant.

The development and operation of parks accounted for the smallest share of total consolidated expenditures by provincial/territorial governments in 1991 as well as in 1988.

4. These are expenditures associated with the development and conservation of the following resources: agriculture, fish and game, forests, mines, oil and gas and other activities such as the administration of Crown land and energy conservation. See Appendix for more detail.

Table 9.2

Consolidated Capital and Current Expenditures Made by Governments for Environmental Protection by Province, 1991 (Fiscal Year)

	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	thousand dollars												
Consolidated federal/provincial/local government expenditures[1]													
Pollution abatement and control	4 747 032	...	...	...	...	...	...	...	...	...	...	...	...
Natural resource conservation & development[2]	13 305 830	...	...	...	...	...	...	...	...	...	...	...	...
Consolidated provincial/local government expenditures													
Pollution abatement and control													
Sewage collection and disposal	1 955 541	19 420	2 580	63 210	42 898	537 628	838 006	55 495	37 426	146 430	192 799	5 329	14 320
Waste collection and disposal	1 321 232	14 444	3 808	53 844	20 732	267 306	635 900	29 608	18 001	107 937	164 894	864	3 893
Pollution control	265 261	2 956	348	6 103	3 420	-	179 066	746	29 730	42 131	-	-	759
Other environmental services[3]	517 544	1 826	1 490	5 575	19 468	169 533	73 024	10 984	119 213	11 785	103 934	590	122
Total pollution abatement and control	4 059 578	38 646	8 226	128 732	86 519	974 467	1 725 997	96 833	204 368	308 283	461 627	6 784	19 094
Natural resource conservation & development													
Agriculture	4 215 937	15 108	42 418	35 782	39 284	814 655	489 258	459 687	1 144 993	1 073 133	101 006	491	121
Fish and game	335 781	34 140	4 062	7 628	21 611	96 462	85 151	8 538	10 819	31 457	21 921	5 796	8 197
Forests	1 537 011	26 602	6 722	50 064	30 629	310 061	293 912	12 483	81 156	126 184	571 995	848	26 356
Mines, oil and gas	1 167 788	42 329	-	11 567	2 871	78 486	41 690	10 950	316 613	531 617	81 028	1 331	49 308
Other	1 080 652	4 622	5 562	10 429	34 282	150 055	433 042	42 326	30 233	222 741	120 116	6 701	20 544
Total conservation & development	8 337 169	122 801	58 763	115 469	128 676	1 449 719	1 343 053	533 984	1 583 813	1 985 131	896 066	15 167	104 526
Parks[4]	204 624	6 644	3 654	6 838	9 450	32 569	57 214	16 285	15 449	27 559	28 550	412	-

Notes:
Figures may not add due to rounding.
Data provided for fiscal years.
1. Excludes expenditures for parks because data are not available.
2. Estimates from the National Accounts and Environment Division.
3. Local government expenditures for other pollution abatement and control may include expenditures for both pollution control and other environmental services.
4. Include only expenditures for parks by provincial/territorial governments.
Source:
Statistics Canada, Public Institutions Division.

Expenditures by level of government, 1965-1994

PAC expenditures

As Table 9.4 reveals, local governments[1] are responsible for most government PAC expenditures in Canada. In 1991, they spent $3.2 billion on PAC and a total of $3.7 billion was earmarked for 1993. By comparison, consolidated PAC expenditures made by federal and provincial/territorial governments were each less than one billion dollars in 1991.

Local governments devote a larger portion of their budgets to PAC than the other levels of governments. In the early 1990s, however, the portion of their budgets devoted to PAC was no larger than that of the 1960s (5 percent). In contrast, federal and provincial/territorial governments devoted less than one percent of their budgets to PAC.

Between 1965 and 1983, local government PAC expenditures in constant dollars[2] (see Table 9.3) increased at the average annual rate of 2.5 percent. The growth rate more than doubled between 1983 and 1993 to 6 percent a year on average (this rate is higher than the rate of increase of total local government expenditures).

In general provincial/territorial government PAC expenditures in constant dollars increased markedly from 1970 to 1991, with growth rates often exceeding15 percent. In comparison, total expenditures by these governments increased less during these years.

Federal government PAC expenditures in 1986 dollars also increased markedly from 1970 to 1994, at an average annual rate of 26 percent. This rate was much higher than the 4 percent registered for federal government expenditures as a whole for that period.

Local governments

Table 9.4 shows that local governments are mainly responsible for sewage treatment ($2.2 billion in 1993) and for waste disposal ($1.4 billion in 1993). These activities are partly financed by provincial/territorial government transfers as will be seen later on. The portion of sewage treatment in PAC expenditures declined from 73 percent to 60 percent

1. Local government expenditures exclude inter-municipal transfers.

2. Growth rates of the various categories of expenditures in constant dollars are calculated from estimations at 1986 prices, which are made by applying the implicit price index of total government expenditures. The index for Canada is presented in Table 9.9 from 1965 to 1994. Provincial estimates in constant 1986 dollars are available since 1971 (since 1977 for the territories).

Table 9.3
Expenditures for Pollution Abatement and Control by Level of Government, 1965-1994 (Fiscal Years)

Year	Federal	Provincial/territorial	Local
	thousand 1986 dollars		
1965-66	..	..	1 164 119
1966-67	..	..	1 192 934
1967-68	..	..	1 296 202
1968-69	..	..	1 332 146
1969-70	..	..	1 218 960
1970-71	30 136	50 545	1 180 471
1971-72	73 907	114 576	1 311 940
1972-73	317 110	243 484	1 428 832
1973-74	725 179	318 573	1 651 180
1974-75	693 397	..	1 730 002
1975-76	659 679	299 504	1 858 026
1976-77	627 785	290 250	2 107 822
1977-78	600 053	277 096	2 086 988
1978-79	715 338	263 974	1 919 721
1979-80	580 257	332 487	1 865 530
1980-81	502 859	469 290	1 963 645
1981-82	454 807	544 576	1 852 088
1982-83	544 977	378 703	1 681 456
1983-84	538 697	379 072	1 746 082
1984-85	523 586	569 983	1 625 214
1985-86	433 644	..	1 671 661
1986-87	445 727	..	1 842 685
1987-88	481 242	..	1 942 980
1988-89	493 656	486 966	2 147 721
1989-90	546 502	599 540	2 465 506
1990-91	588 406	747 579	2 736 272
1991-92	582 512	885 214	2 703 442
1992-93[1]	579 549	..	2 928 412
1993-94[2]	602 090	..	2 997 882
1994-95[3]	745 226	..	..

Notes:
Figures represent non consolidated current and capital expenditures.
Expenditures in 1986 dollars have been estimated using the implicit price index of total government expenditures.
Figures may not add due to rounding.
1. In 1992-93 local government data are estimates.
2. In 1993-94 federal government data are revised estimates while local government data are preliminary estimates.
3. In 1994-95 federal government data are estimates.
Sources:
Statistics Canada, National Accounts and Environment Division and Public Institutions Division.

between 1965 and 1993, while the portion of expenditures on waste collection and disposal increased. Expenditures on waste collection and disposal represented close to 40 percent of local government PAC expenditures in 1993 compared to 25 percent in 1965. Expenditures for other environmental services[1] made up 3 percent of local government PAC expenditures in 1993 and were financed mainly by provincial/territorial transfers.

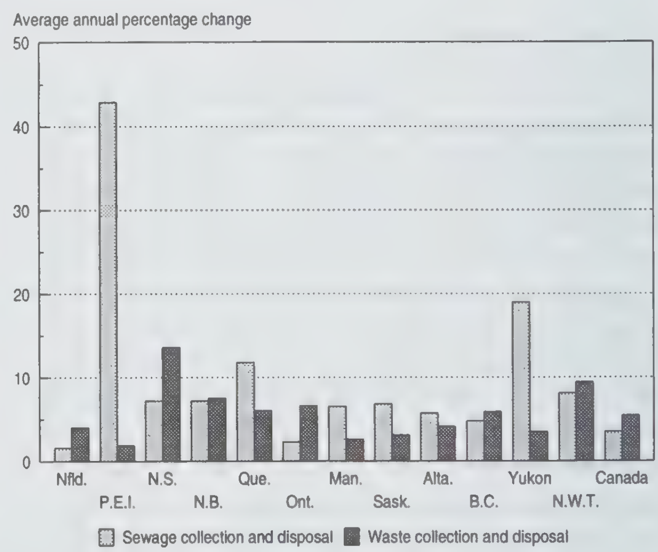
The most recent data from the Survey of Local Government Waste Management Practices[2] show that, in 1993, waste collection was mainly contracted out. Also, part of local government waste treatment expenditures was used to purchase recycling services, since almost 70 percent of the municipalities surveyed declared having such programmes. In British Columbia for instance, an integrated solid waste management strategy was adopted ("Reduce, Re-use and Recycle") to finance assistance programmes destined for municipalities. Other waste management activities financed by municipalities in Canada in 1993 included hazardous waste, compost collection and public education programmes and studies on waste composition.

Waste disposal expenditures by local governments in 1986 dollars had an average annual growth rate of 5 percent between 1971 and 1993, as shown in Figure 9.1. This rate was higher than the rate of increase of total local government expenditures in Canada (3 percent). Expenditures on sewage disposal increased at an average annual rate of 3.5 percent since 1971. This translated into more municipal sewage facilities, particularly tertiary treatment facilities[3]. The Canadian population serviced by municipal wastewater treatment facilities increased from 72 percent to 84 percent between 1983 and 1991. In Prince Edward Island the average annual growth rate was over 40 percent since 1971 as shown in Figure 9.1.The real growth of waste and sewage collection

1. Local government expenditures for other environmental services may also include expenditures specific to pollution control.
2. See article by M. Cameron, in this issue, Chapter 3.

3. Figures obtained from ***Human Activity and the Environment 1994***, Cat. No. 11-509E, Table 4.2.2, p. 191.

Figure 9.1
Average Annual Rate of Growth of Local Government Expenditures for Sewage and Waste Collection and Disposal in 1986 Dollars, by Province, 1971-1993.



Notes:
Estimates in 1986 dollars were calculated from implicit price indices of total government expenditures (current and capital), for each province and for Canada as a whole.
In P.E.I. changes in local government expenditures for sewage collection and disposal were highly irregular.
Sources:
Statistics Canada, National Accounts and Environment Division and Public Institutions Division.

Table 9.4

Expenditures for Pollution Abatement and Control by Level of Government, 1965-1994 (Fiscal Years)

Year	Federal				Provincial/territorial					Local			
	Sewage disposal[4]	Pollution control	Other environmental services	Total PAC	Sewage disposal[4]	Waste disposal[4]	Pollution control	Other environmental services	Total PAC	Sewage disposal[4]	Waste disposal[4]	Other environmental services[5]	Total PAC
	thousand dollars												
1965-66	..	..	..	..	..	..	..	..	..	176 115	60 931	2 783	239 829
1966-67	..	..	..	..	..	..	..	..	..	193 563	66 894	3 096	263 553
1967-68	..	..	..	..	..	..	..	..	..	221 624	75 794	3 744	301 162
1968-69	..	..	..	..	..	..	..	..	..	238 156	81 667	4 021	323 844
1969-70	..	..	..	..	..	..	..	..	..	235 598	79 164	3 654	318 416
1970-71	8 297	-	-	8 297	-	-	10 227	3 689	13 916	240 072	81 272	3 664	325 008
1971-72	15 135	-	6 487	21 622	-	-	25 543	7 977	33 520	270 755	108 357	4 704	383 816
1972-73	27 097	-	72 296	99 393	-	-	62 455	13 861	76 316	325 260	117 707	4 877	447 844
1973-74	39 239	18 452	186 724	244 415	-	-	77 192	30 180	107 372	418 857	131 498	6 160	556 515
1974-75	32 049	23 273	213 472	268 794	..	..	..	..	..	490 109	169 751	10 772	670 632
1975-76	52 678	25 307	211 446	289 431	-	-	72 591	58 815	131 406	569 483	229 544	16 173	815 200
1976-77	73 734	28 596	204 468	306 798	-	-	87 080	54 765	141 845	763 087	245 144	21 859	1 030 090
1977-78	48 552	33 263	235 096	316 911	-	-	69 293	77 052	146 345	792 146	282 594	27 478	1 102 218
1978-79	113 914	36 258	254 949	405 121	-	-	69 916	79 582	149 498	725 503	315 782	45 921	1 087 206
1979-80	84 006	30 162	245 503	359 671	-	-	80 011	126 080	206 091	772 367	329 051	54 926	1 156 344
1980-81	69 378	35 474	238 001	342 853	-	-	102 991	216 974	319 965	890 198	390 894	57 735	1 338 827
1981-82	38 446	40 190	271 318	349 954	-	-	300 329	118 698	419 027	965 935	408 923	50 241	1 425 099
1982-83	50 421	44 742	370 909	466 072	-	-	193 034	130 838	323 872	938 213	456 641	43 150	1 438 004
1983-84	16 661	56 249	413 285	486 195	-	-	157 938	184 189	342 127	996 524	528 306	51 076	1 575 906
1984-85	12 986	58 649	419 697	491 332	-	-	148 832	386 039	534 871	967 211	514 442	43 445	1 525 098
1985-86	2 284	55 941	363 908	422 133	..	..	..	..	..	992 875	564 362	70 051	1 627 288
1986-87	-	61 983	383 744	445 727	..	..	..	..	..	1 138 023	627 753	76 909	1 842 685
1987-88	-	67 297	430 794	498 091	..	..	..	..	..	1 208 602	714 493	87 911	2 011 006
1988-89	-	87 142	442 869	530 011	77 526	54 022	226 639	164 641	522 828	1 413 609	817 079	75 200	2 305 888
1989-90	-	113 085	497 185	610 270	72 412	114 495	280 066	202 524	669 496	1 734 756	935 818	82 615	2 753 189
1990-91	-	118 855	571 471	690 326	75 327	125 943	296 300	379 501	877 071	2 001 997	1 125 905	82 331	3 210 233
1991-92	-	20 221	682 955	703 176	100 597	160 863	341 901	465 220	1 068 580	1 954 272	1 228 222	80 949	3 263 443
1992-93[1]	150	4 329	709 679	714 158	..	..	..	..	..	2 126 725	1 389 774	92 083	3 608 582
1993-94[2]	275	1 004	749 906	751 185	..	..	..	..	..	2 236 357	1 406 330	97 558	3 740 245
1994-95[3]	-	5 870	929 389	935 259	..	..	..	..	..	..	..	..	..

Notes:
Figures represent non consolidated current and capital expenditures.
Figures may not add due to rounding.
Data are expressed on a Financial Management System basis.
For a breakdown of provincial and local government expenditures see Annex, Table 13.
1. In 1992-93 local government data are estimates.
2. In 1993-94 federal government data are revised estimates while local government data are preliminary estimates.
3. In 1994-95 federal government data are estimates.
4. Includes collection expenditures as well.
5. May also include expenditures specific to pollution control.
Sources:
Statistics Canada, ***Federal Government Finance***, Cat. No. 68-211; ***Provincial Government Finance - Revenue and Expenditure***, Cat. No. 68-207 and Public Institutions Division.

and disposal expenditures accelerated between 1983 and 1993 compared with the growth over the 1971-1983 period. The average annual growth rate of sewage expenditures increased from 2 to 5 percent between the two periods while the average annual growth rate of waste expenditures increased from 4 to 7 percent. Expenditures on other environmental services saw their average annual growth rate decline from 14 to 5 percent between the 1971-1983 and 1983-1993 periods. This attests to an increasing focus of local government activities on waste disposal and sewage treatment.

Between 1983 and 1993, local governments were allocating more for the maintenance of PAC infrastructure and equipment than for PAC investment. Since the beginning of the 1990s current expenditures of local governments were twice as high as capital expenditures (see Table 9.5). However, most sewage treatment expenditures were for capital. Capital expenditures on PAC represented 14 percent of total municipal investment in Canada in 1993. Current expenditures on PAC represented less than 4 percent of total current expenditures.

Federal government

As shown in Table 9.4, federal government PAC expenditures made at the beginning of the 1990s were almost entirely on other environmental services such as Environment Canada's administrative services, environmental assessments and in 1994, elements of the federal government's infrastructure programme. A much lower amount was allotted specifically for pollution control. In earlier years the federal government was also involved in financing sewage treatment systems. Federal transfers to provincial/territorial and local governments have declined considerably since the 1970s relative to other types of PAC expenditures. In 1970-71, these transfers were the only means of financing PAC expenditures while in 1991-92, they accounted for less than 3 percent of all federal PAC expenditures.

Federal government PAC expenditures are mostly directed to implementing and applying environmental protection legislation (e.g. Canadian Environmental Protection Act, Fisheries Act). Environment Canada shares the responsibility of most federal PAC programmes. Some of these include the St. Lawrence River Action Plan, the Great Lakes Action Plan, the National Contaminated Sites programme, research on global change (e.g., research on the greenhouse effect), etc.

Provincial and territorial governments

From 1970 to the mid 1980s, provincial/ territorial PAC expenditures were only made for specific pollution control activities and for other environmental services. The relative importance of both activities varies from year to year but, in general, the share of expenditures on other environmental services increased considerably, from 26.5 percent in 1970 to 72 percent in 1984. This was at the expense of specific pollution control expenditures which saw their share of total PAC expenditures decline in the same proportions. Therefore, it seems that between 1970 and 1984, provincial/territorial governments gradually turned away from specific pollution control programmes toward more general activities such as environmental assessments, the administration of the environment departments, etc.

Statistics on expenditures for waste treatment and sewage disposal activities were first available in 1988 as shown in Table 9.4. However, expenditures for sewage disposal saw their share of PAC expenditures decrease between 1988 and 1991 (from 15 percent to 9 percent) and only British Columbia, New Brunswick, Nova Scotia and the Yukon have spent money on sewage treatment for the past three or four years.[1] The governments of Quebec, Saskatchewan and the Northwest Territories had no expenditures for waste

Table 9.5

Detail of Total Provincial/Territorial and Local Government Expenditures for Pollution Abatement and Control, 1991-92

	Sewage collection and disposal		Waste collection and disposal		Pollution control		Other PAC		Total PAC	
	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)
PROVINCIAL/TERRITORIAL										
Current expenditures on goods & services	234	0.2	27 798	17.3	221 542	64.8	241 683	52.0	491 256	46.0
Capital expenditures	573	0.6	2 376	1.5	7 390	2.2	12 312	2.6	22 651	2.1
Other expenditures on goods & services	-	-	26 616	16.5	1 051	0.3	64 094	13.8	91 762	8.6
Transfer payments to persons	463	0.5	1 911	1.2	5 582	1.6	19 966	4.3	27 922	2.6
Transfer payments to business	-	-	3 862	2.4	7 358	2.2	31 531	6.8	42 751	4.0
Transfer payments to municipalities	99 328	98.7	66 274	41.2	76 640	22.4	28 625	6.2	270 867	25.3
Transfer payments to schools	-	-	638	0.4	-	-	-	-	638	0.1
Transfer payments to hospitals	-	-	940	0.6	-	-	-	-	940	0.1
Expenditure reconciliation and integration	-	-	27 434	17.1	-	-	5 840	1.3	33 274	3.1
Revenue/receipts offset against expenditure	-	-	-	-	-102	-	-662	-0.1	-765	-0.1
Adjustments[1]	-	-	3 013	1.9	22 440	6.6	61 829	13.3	87 282	8.2
Total provincial/territorial	**100 597**	**100.0**	**160 863**	**100.0**	**341 901**	**100.0**	**465 220**	**100.0**	**1 068 580**	**100.0**
LOCAL										
Current expenditures on goods & services	892 546	45.7	1 068 407	87.0	-	-	66 222	81.8	2 027 180	62.1
Capital expenditures	1 061 726	54.3	159 815	13.0	-	-	14 727	18.2	1 236 270	37.9
Total local	**1 954 272**	**100.0**	**1 228 222**	**100.0**	**-**	**-**	**80 949**	**100.0**	**3 263 440**	**100.0**

Notes:
Figures may not add due to rounding.
1. Adjustments are made in order to reconcile data from the System of National Accounts classification and data from the Financial Management System classification.
2. Local government expenditures specific to pollution control and for other environmental services are included in other pollution abatement and control expenditures.
Source:
Statistics Canada, Public Institutions Division.

treatment, leaving waste management responsibilities to local governments. At the other extreme, waste treatment accounted for the highest PAC expenditures by the Government of Prince Edward Island (see Annex, Table 13).

In 1991, other environmental services, worth over $465 million, were still the highest items of PAC expenditures for provincial and territorial governments. A considerable part of this expenditure was for administration of the ministries of the environment. Specific pollution control expenditures had their share of PAC expenditures increase between 1984 and 1988 before declining from 43 percent to 32 percent between 1988 and 1991 in spite of an increase in size. Some of the major government PAC expenditures partly managed or financed by the provinces include: the Municipal-Industrial Strategy for Abatement (MISA) in Ontario which aims at reducing water pollution, Ontario's participation in the Great Lakes Action Plan, Quebec's participation in the St. Lawrence River Action Plan, and British Columbia's contribution to the Fraser River Basin Action Plan (particularly the provincial Fraser River Estuary Management programme).

More detailed data on the composition of provincial/territorial expenditures exist. As shown in Table 9.5 for 1991, the size of transfers to municipalities and schools and hospitals for PAC purposes varies considerably by type of expenditure category. The largest transfer payments were made to finance sewage treatment ($99.3 million in 1991); they were followed by specific pollution control transfers (distributed among the different categories of municipal PAC expenditures), transfers for waste treatment and other transfers. In the case of British Columbia, all provincial government expenditures on sewage treatment made between 1988 and 1991 were in the form of transfers to municipalities. Only the Government of Newfoundland did not make transfer payments for PAC.

The financing of PAC expenditures through transfers to municipalities was not the only form of financing by provincial/territorial governments. As Table 9.5 reveals, over half of all expenditures specific to pollution control and on other environmental services were made for current purchases of goods and services in 1991. Expenditures on other environmental services consisted partly of purchase of unspecified goods and services and transfer payments to businesses. Almost 20 percent of waste treatment expenditures were current expenditures on goods and services.

Expenditures on natural resource conservation and development

Federal and provincial/territorial governments support various activities which encourage sustainable development and natural resource conservation as shown in Table 9.7.

1. It is possible that in other provinces, particularly in Quebec and Ontario, sewage disposal expenditures were included in the water supply category, due to the nature of certain provincial programmes for financing sewage systems and aqueducts.

Provincial/territorial governments spent $8 billion in 1991 for natural resource conservation and development. Throughout the 1988-1991 period, few transfers were paid to other governments for resource conservation and development. Conservation and development expenditures accounted for close to 5 percent of total expenditures by provincial/territorial governments in 1991. This ratio increased compared with the 1970 ratio of 3 percent but has been declining since the peak of 6 percent in 1982.

Table 9.6

Expenditures for Natural Resource Conservation and Development by Level of Government, 1965-1994 (Fiscal Years)

Year	Federal	Provincial/territorial	Local
	thousand 1986 dollars		
1965-66	..	..	55 311
1966-67	..	..	187 038
1967-68	..	..	111 685
1968-69	..	..	92 061
1969-70	..	..	129 267
1970-71	2 427 388	1 727 491	73 442
1971-72	2 587 840	1 887 666	34 547
1972-73	2 892 979	1 868 396	156 126
1973-74	3 776 026	2 096 909	165 716
1974-75	6 547 176	..	167 758
1975-76	7 373 301	3 061 520	157 880
1976-77	5 633 326	3 443 366	172 311
1977-78	5 206 971	3 487 097	184 698
1978-79	4 423 174	3 663 245	209 328
1979-80	6 740 367	3 988 179	278 814
1980-81	8 952 678	4 432 080	288 002
1981-82	9 040 159	4 851 356	240 483
1982-83	9 816 259	6 106 317	315 134
1983-84	8 201 312	5 523 942	300 220
1984-85	10 171 587	5 528 891	276 578
1985-86	6 885 778	..	288 669
1986-87	5 649 440	..	338 145
1987-88	6 829 863	..	353 897
1988-89	5 397 005	5 674 324	326 218
1989-90	4 319 564	6 064 719	372 884
1990-91	3 739 675	5 472 295	402 680
1991-92	5 186 693	6 642 873	411 926
1992-93[1]	4 146 417	..	368 948
1993-94[2]	3 927 788	..	341 539
1994-95[3]	3 448 337	..	..

Notes:
Figures represent non consolidated current and capital expenditures.
Expenditures in 1986 dollars have been estimated using the implicit price index of total government expenditures.
Figures may not add due to rounding.
1. In 1992-93 local government data are estimates.
2. In 1993-94 federal government data are revised estimates while local government data are preliminary estimates.
3. In 1994-95 federal government data are estimates.
Sources:
Statistics Canada, National Accounts and Environment Division and Public Institutions Division.

Federal government expenditures on conservation and development amounted to $6.3 billion in 1991, and then decreased to $4.3 billion in 1994. Federal expenditures on resource conservation and development accounted for approximately 3 percent of total federal government expenditures at the start of the 1990s.

In general, provincial/territorial government expenditures on resource conservation and development have increased

sharply in real terms since 1970 as shown in Table 9.6. The average annual growth rate exceeded 6 percent since 1970. Federal government expenditures increased in real terms at an average rate of 4.5 percent per year between 1970 and 1994.

Federal government

As shown in Table 9.7, in the area of natural resource conservation and development, the federal government is primarily involved in programmes to develop agriculture. They accounted for over half of all federal conservation and development expenditures since the mid 1980s, although expenditures for agriculture decreased from $4.6 billion in 1991 to $2.4 billion in 1994. These programmes are mainly aimed at stabilizing prices and providing subsidies to farmers although part of the expenditures on agriculture also went to the National Soil Conservation programme and to research on global change. Expenditures on fish and game, the second highest expenditures also have declined since 1991. The North American Wildfowl Management Plan and the Environmental Effects Monitoring programme (monitoring of the effects of industrial activity on fish resource and its habitat) are examples of fish and game conservation programmes. Expenditures on mines, oil and gas declined significantly between 1984 and 1994, from $6 billion to $569 million. Several expenditures though were subsidies to Crown corporations designed to encourage mining exploration rather than conservation *per se.*

Table 9.7

Expenditures for Natural Resource Conservation & Development by Level of Government, Canada, 1965-1994 (Fiscal Years)

	Federal						Provincial/territorial						Local		
	Agriculture	Fish & game	Forests	Mines, oil and gas	Other	Total	Agriculture	Fish & game	Forests	Mines, oil and gas	Other	Total	Agriculture	Other	Total
	thousand dollars														
1965-66	..	..	..	..	..	..	..	..	..	..	..	..	770	10 625	11 395
1966-67	..	..	..	..	..	..	..	..	..	..	..	..	1 006	40 316	41 322
1967-68	..	..	..	..	..	..	..	..	..	..	..	..	1 187	24 762	25 949
1968-69	..	..	..	..	..	..	..	..	..	..	..	..	1 044	21 336	22 380
1969-70	..	..	..	..	..	..	..	..	..	..	..	..	898	32 869	33 767
1970-71	447 213	71 241	22 998	70 305	56 553	668 310	211 596	27 328	136 748	30 943	68 999	475 614	1 161	19 059	20 220
1971-72	540 633	73 182	23 559	48 606	71 108	757 088	229 339	39 852	174 252	37 593	71 212	552 248	461	9 646	10 107
1972-73	635 986	120 248	30 091	38 428	82 004	906 757	272 780	43 363	157 765	41 428	70 282	585 618	810	48 125	48 935
1973-74	710 302	110 241	1 241	319 843	131 048	1 272 675	321 265	61 091	177 347	51 305	95 736	706 744	1 042	54 811	55 853
1974-75	963 000	141 000	1 000	1 295 000	138 000	2 538 000	..	..	..	..	..	..	1 918	63 113	65 031
1975-76	1 262 000	181 000	1 000	1 629 000	162 000	3 235 000	635 598	104 166	290 304	169 592	143 567	1 343 227	9 320	59 949	69 269
1976-77	1 335 000	206 000	2 000	993 000	217 000	2 753 000	691 199	103 996	317 983	426 931	142 660	1 682 769	36 562	47 646	84 208
1977-78	1 287 000	217 000	2 000	977 000	267 000	2 750 000	738 299	122 042	369 138	408 672	203 518	1 841 669	46 335	51 211	97 546
1978-79	1 274 000	251 000	2 000	720 000	258 000	2 505 000	677 979	137 321	427 373	556 224	275 728	2 074 625	55 882	62 668	118 550
1979-80	1 564 000	252 000	4 000	2 104 000	254 000	4 178 000	908 494	154 777	510 187	579 410	319 195	2 472 063	76 736	96 086	172 822
1980-81	1 316 000	292 000	59 000	4 125 000	312 000	6 104 000	1 136 035	167 746	711 757	621 797	384 489	3 021 824	91 690	104 672	196 362
1981-82	1 681 000	356 000	75 000	4 382 000	462 000	6 956 000	1 459 124	184 363	803 015	706 539	579 861	3 732 902	77 023	108 018	185 041
1982-83	1 679 000	386 000	97 000	5 489 000	744 000	8 395 000	1 509 956	211 670	824 805	1 933 967	741 809	5 222 207	114 735	154 772	269 507
1983-84	1 819 000	502 000	117 000	4 429 000	535 000	7 402 000	1 527 207	209 810	837 733	1 584 565	826 255	4 985 570	139 809	131 151	270 960
1984-85	2 226 000	595 000	164 000	5 947 000	613 000	9 545 000	1 825 725	230 214	903 486	1 379 276	849 601	5 188 302	141 630	117 910	259 540
1985-86	2 427 000	510 000	200 000	2 943 000	623 000	6 703 000	..	..	..	..	..	..	145 000	136 006	281 006
1986-87	3 238 424	388 334	224 701	1 094 982	702 999	5 649 440	..	..	..	..	..	..	184 946	153 199	338 145
1987-88	4 720 872	328 401	660 250	708 981	650 481	7 068 985	..	..	..	..	..	..	170 102	196 185	366 287
1988-89	3 614 209	393 464	311 776	767 246	707 769	5 794 464	2 726 916	302 864	1 247 665	977 089	837 672	6 092 206	124 297	225 945	350 242
1989-90	3 011 498	402 070	284 463	365 551	760 003	4 823 585	2 834 386	342 942	1 394 897	1 340 073	860 072	6 772 370	163 413	252 980	416 393
1990-91	2 592 673	470 382	215 421	383 426	725 538	4 387 440	2 901 736	349 733	1 413 677	990 898	764 131	6 420 174	156 099	316 331	472 430
1991-92	4 622 131	483 973	206 653	325 310	623 016	6 261 083	4 168 575	338 934	1 537 011	1 167 788	806 594	8 018 902	168 376	328 878	497 254
1992-93[1]	3 237 913	693 646	236 048	321 573	620 308	5 109 488	..	..	..	..	..	..	146 683	307 959	454 642
1993-94[2]	2 881 503	692 158	237 655	497 388	591 718	4 900 422	..	..	..	..	..	..	139 388	286 726	426 114
1994-95[3]	2 436 523	573 942	225 869	568 992	522 337	4 327 663	..	..	..	..	..	..	..	..	..

Notes:
Figures represent non consolidated current and capital expenditures.
Figures may not add due to rounding.
Data are expressed on a Financial Management System basis.
For a breakdown of provincial and local government expenditures, see Annex, Table 13.
1. In 1992-93 local government data are estimates.
2. In 1993-94 federal government data are revised estimates while local government data are preliminary estimates.
3. In 1994-95 federal government data are estimates.
Sources:
Statistics Canada, ***Federal Government Finance***, Cat. No. 68-211; ***Provincial Government Finance - Revenue and Expenditure***, Cat. No. 68-207; Public Institutions Division.

Table 9.8

Detail of Provincial/Territorial Government Expenditures for Natural Resource Conservation and Development and for Parks, Canada, 1991-92

	Agriculture		Fish and game		Forests		Mines, oil and gas		Other natural resource conservation & development		Total natural resource conservation & development		Parks	
	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)	thousand dollars	share of total (%)
Current expenditures on goods & services	754 753	18.1	177 221	52.3	1 088 391	70.8	269 916	23.1	781 528	96.9	3 071 810	38.3	185 116	90.4
Capital expenditures	23 816	0.6	8 427	2.5	57 532	3.7	6 524	0.6	19 452	2.4	115 750	1.4	13 652	6.7
Other expenditures on goods & services	86 263	2.1	29 845	8.8	181 849	11.8	15 251	1.3	38 238	4.7	351 445	4.4	11 755	5.7
Transfer payments to persons	71 584	1.7	6 686	2.0	6 319	0.4	15 831	1.4	7 112	0.9	107 532	1.3	513	0.3
Transfer payments to business	3 078 903	73.9	23 332	6.9	61 176	4.0	191 310	16.4	177 019	21.9	3 531 740	44.0	123	0.1
Transfer payments from provincial to federal governments	43 851	1.1	-	-	-	-	-	-	-	-	43 851	0.5	-	-
Transfer payments to municipalities	77 163	1.9	3 153	0.9	-	-	-	-	54 820	6.8	135 137	1.7	89	-
Interest on public debt	1	-	-	-	-	-	-	-	-	-	1	-	-	-
Expenditure reconciliation and integration	47 526	1.1	6 431	1.9	4 823	0.3	44 015	3.8	3 528	0.4	106 323	1.3	60	-
Direct taxes	-	-	-	-	-	-	43 452	3.7	-	-	43 452	0.5	-	-
Indirect taxes	-	-	-	-	-7 000	-0.5	-	-	-	-	-7 000	-0.1	-	-
Revenue/receipts offset against expenditure	-11 559	-0.3	-150	-	-1 309	-0.1	-180	-	-1 853	-0.2	-15 053	-0.2	-	-
Intra subsectorial transfers	-	-	-	-	-	-	-	-	-4 191	-0.5	-4 191	-0.1	-	-
Adjustments[1]	-3 725	-0.1	83 989	24.8	145 230	9.4	581 671	49.8	-269 059	-33.4	538 105	6.7	-6 596	-3.2
Total	**4 168 575**	**100.0**	**338 934**	**100.0**	**1 537 011**	**100.0**	**1 167 788**	**100.0**	**806 594**	**100.0**	**8 018 902**	**100.0**	**204 713**	**100.0**

Note:
1. Adjustments are made in order to reconcile data from the System of National Accounts classification and data from the Financial Management System classification.
Source:
Statistics Canada, Public Institutions Division.

Most of federal government transfer payments to provinces, territories and municipalities for natural resource conservation and development ($1 billion in 1991) went to agriculture. This constitutes a significant change compared with the 1970s and 1980s when transfers to mines, oil and gas represented more than half of all federal transfers for resource conservation and development.

Provincial/territorial governments

As shown in Table 9.7, agriculture also accounted for close to half of all provincial/territorial resource conservation and development expenditures since 1989. In fact since 1970 agriculture has represented a growing share of conservation and development expenditures. One of the programmes, in this regard, Ontario's Land Management Programme, is aimed at ensuring improved conservation of the province's agricultural land. Forest conservation and development accounted for the second highest group of expenditures, representing 19 percent of total provincial/territorial expenditures for conservation and development in 1991, although this ratio declined since 1971. Expenditures on mines, oil and gas accounted for almost 15 percent of conservation and development expenditures in 1991; this ratio has also declined since 1980. The other resource conservation and development expenditures accounted for 10 percent of the 1991 total. This ratio is also on the decline since the beginning of the 1980s.

As shown in Table 9.8, transfer payments to the other levels of government accounted for just 2 percent of resource conservation and development expenditures by provincial/territorial governments in 1991.

Transfer payments to business accounted for 44 percent of total natural resource conservation and development expenditures, and mainly consisted of payments in agricul-

ture. Current expenditures accounted for 38 percent of total resource conservation and development expenditures, and were shared mainly among agriculture, forests and other natural resource and development activities.

Local governments

Local governments spent $139.4 million in 1993 on the conservation and development of agricultural resources and these expenditures grew at an average annual rate of 27 percent between 1965 and 1993. Local governments also spent $286.7 million in 1993 on other natural resources such as energy, and these expenditures increased at an average annual rate of 20.5 percent between 1965 and 1993.

Parks

The final category of environmental protection expenditure under review is the development and operation of parks. The Green Plan actually stressed the need to protect 12 percent of the land and to complete the national parks system by the year 2000. Provincial/territorial governments spent $204.7 million in 1991 for the development and operation of parks, an increase from $192.3 million in 1988. Almost all consisted of current expenditures on goods and services (90 percent in 1991), and the rest were mostly investments and other expenditures on goods and services (see Table 9.8).

Conclusion

Consolidated government environmental protection expenditures in Canada, estimated at $18 billion in 1991, are broken down between PAC expenditures ($4.7 billion) and natural resource conservation and development expenditures ($13.3 billion). Expenditures for parks should also be included but for the moment only data on provincial/territorial government expenditures are available since federal government data have yet to be reconciled with the conceptual framework of environmental protection expenditures. PAC expenditures represent one percent of total consolidated government expenditures in Canada and for more than thirty years have been mostly made by local governments. Local governments are mainly responsible for sewage treatment and waste disposal. Expenditures for other environmental services are made mostly by federal and provincial/territorial governments while specific expenditures for pollution control are almost exclusively made by provincial/territorial governments.

Expenditures on natural resource conservation and development are almost exclusively made by provincial/territorial governments and by the federal government. The largest expenditures in this respect are classified under the conservation and development of agriculture, although these expenditures are mostly subsidies to farmers. Indeed, data on the various categories of resource conservation and development expenditures do not separate the specific amounts related to the conservation of soils, forests, waters, mineral resources and the protection of fauna. There is an ongoing project to collect more information on government environmental protection expenditures through detailed analysis of the different sources of administrative data on expenditures by federal and provincial/territorial government departments. Eventually this work should provide more detail on the nature of resource conservation and development activities and more data on park expenditures. Other activities which relate to environmental protection such as regional planning and development might also be included.

Appendix: Definitions and data quality

Environmental protection expenditures by governments in Canada are defined as expenditures by federal, provincial/territorial and local governments that are undertaken with the sole aim of preventing, reducing and abating degradation of the natural environment or to preserve the environment. The following activities are included in this definition:

1. Pollution abatement and control (PAC)
   - protection of ambient air and climate
   - protection of surface water
   - waste collection and treatment
   - protection of soil and groundwater
   - protection against noise, vibration and radiation
   - research and development on PAC
   - other environmental services (e.g education, administration of the ministry of environment)
2. Conservation
   - wildlife and habitat
   - soil
   - mineral resources
   - forests
   - waters

Classification of expenditures according to the financial management system

In practice, data on government expenditures available at Statistics Canada are classified by function based on the Financial Management System (FMS) of government revenues and expenditures.

1. **PAC expenditures** are included in the 'environment' function of the FMS under the following categories:

- Sewage collection and disposal (sewage treatment): expenditures on the construction and maintenance of sewage removal and treatment facilities (including sanitary sewers and combined sanitary-storm sewers), expenditures related to inspection and cleaning of sewers, and subsidies related to assistance and research in this area.
- Waste collection and disposal (waste treatment or waste management): expenditures on construction and maintenance of garbage and waste collection and disposal (including landfill sites, incineration, recycling and landfill site cleanup), and on managing waste collection and disposal programmes.
- Pollution control: all expenditures to prevent or reduce air, water, soil or groundwater pollution.
- Other environmental services (not elsewhere specified): expenditures for such services as general administration of the ministry of environment, education, environmental assessments, contributions to environmental agencies, etc.

The 'environment' classification includes expenditures for water supply and distribution. However these expenditures are excluded from environmental protection expenditures because they relate to human health protection rather than to environmental protection. Data on government expenditures for the 'environment' function are published on a regular basis, by level of government, both at the consolidated and non consolidated levels.

2. **Natural resource conservation and development**

These expenditures are classified under the 'Natural Resource Conservation and Industrial Development' function of the FMS but exclude the categories 'tourism', 'trade and industrial development' as well as the category 'water power'. Water power includes control of damage due to floods and the installation of dams. Natural resource conservation and development activities include the following expenditures:

- Agriculture: expenditures for research, price stabilisation, soil conservation and protection against soil erosion, farm subsidies, drainage expenditures, etc.
- Fish and game: expenditures for research and management of fish and wildlife including expenditures for aquaculture as well as wildlife habitat protection expenditures, etc.
- Forests: expenditures for research, pest control, control of fires, expenditures for construction of logging roads, reforestation, etc.
- Mines, oil and gas: expenditures related to research, exploitation and conservation of mining resources.
- Other: expenditures related to the management of Crown land, energy conservation, subsidies to conservation agencies for energy related R&D, etc.

Data on government expenditures for the 'natural resource conservation and industrial development' function are published on a regular basis, by level of government, both at the consolidated and non consolidated levels.

3. **Parks**

Park expenditures are a component of the 'Recreation and Culture' function of the FMS. They comprise all expenditures associated with implementing and maintaining national, regional, provincial and municipal parks. Only data on expenditures by provincial/ territorial governments from 1988-89 to 1991-92 provide this amount of detail.

Available detail

Data on expenditures by provincial/territorial governments from 1988 to 1991 are produced using both an FMS classification and an economic classification (System of National Accounts). In order to reconcile the data from the two classifications, it is necessary to take account of differences in the methodologies.

The System of National Accounts classification is made up of the following elements:

- current expenditures on goods and services
- capital expenditures
- expenditures on non-specified goods and services
- transfers to individuals
- transfers to businesses
- transfers to local governments and to other levels of government
- interest payments on public debt
- expenditure reconciliation and integration (expenditures not specified above)
- direct and indirect taxes
- revenues/receipts offset against expenditures

Assets of the Capital and Repair Expenditure Survey

Statistics Canada's Capital Repair and Expenditure Survey provides figures on capital expenditures for PAC construction and machinery and equipment, and construction and equipment used for waste and sewage disposal from 1985 to 1992 (calendar years). These assets include the following:

- construction related to PAC
- waste disposal facilities
- construction of sewage networks: sewage treatment and disposal plants including pumping stations; sanitary and storm sewers, trunk and collection lines, open storm ditches and laterals; lagoons, and any other sewage system construction.
- PAC equipment
- sanitation equipment

Table 9.9
Implicit Price Index, Total Government Expenditure, 1986=100.0

Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Index	20.6	22.1	23.2	24.3	26.1	27.5	29.3	31.3	33.7	38.8	43.9	48.9	52.8	56.6	62.0

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Index	68.2	76.9	85.5	90.3	93.8	97.3	100.0	103.5	107.4	111.7	117.3	120.7	123.2	124.8	125.5

Source:
Statistics Canada, National Accounts and Environment Division.

Method of deflation

Estimates in constant dollars were produced from implicit price indexes of total government expenditures obtained from the national accounts with 1986 as the base year (see Table 9.9). A similar price index was calculated for each province and territory for the 1971-1993 period (1977-1993 period for the territories). These indices are crude approximations. Specific price indices for PAC and other environmental protection expenditures are not available.

References

Statistics Canada, 1992, ***Public Finance, Historical Data 1965/66-1991/92 Financial Management System***, Cat. No. 68-512.

_____, 1994, ***Human Activity and the Environment 1994***, Cat. No. 11-509E, Ottawa.

_____, ***Federal Government Finance***, Cat. No. 68-211 (discontinued).

_____, ***Provincial Government Finance - Revenue and Expenditure***, Cat. No. 68-207 (discontinued).

Annex: Environment and Natural Resource Statistics

Table 1

Selected Environmental Quality Statistics, 1961-1994

	Source	1961	1966	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
AIR QUALITY														
Urban ground level[1]														
Average station exceedances for SO_2, NO_x and CO	a	..	..	..	..	..	..	..	..	..	..	..	9.8	6.6
Average station exceedances for ozone	a	..	..	..	..	..	..	..	..	..	..	..	25.4	23.7
Average station exceedances for particulates	a	..	..	..	..	..	..	..	..	..	..	..	8.2	8.0
Ozone layer[2] (Dobson units[3])														
Toronto	b	346	354	353	353	351	348	349	351	352	350	347	349	350
Edmonton	b	338	353	344	342	341	342	344	343	343	343	341	342	343
Resolute	b	371	377	399	399	388	384	383	374	371	378	384	384	381
Production of CFCs (kt)	b	..	..	..	..	..	..	..	..	..	..	..	17.3	14.0
Production of other ozone depleting substances (kt)	b	..	..	..	..	..	..	..	..	..	..	..	3.4	2.8
Air emissions (thousand tonnes)														
Nitrogen dioxide	c	..	..	1 364	..	..	..	..	1 756	..	..	..	..	1 959
Sulphur dioxide	c	..	..	6 677	..	..	..	..	5 319	..	..	..	..	4 643
Carbon monoxide	c	..	..	10 057	..	..	..	..	10 594	..	..	..	..	10 273
Carbon dioxide from fossil fuel combustion	d	204	278	351	357	375	392	400	393	411	403	409	425	429
Particulates	c	..	..	1 850	..	..	..	..	1 787	..	..	..	..	1 907
LAND														
Agricultural land use (million hectares)														
Cropland	e,f	25.3	27.9	..	27.8	..	..	..	..	28.3	..	..	..	..
Improved pasture	e,f	4.1	4.4	..	4.1	..	..	..	..	4.1	..	..	..	..
Summerfallow	e,f	11.4	10.4	..	10.8	..	..	..	..	10.9	..	..	..	..
Other land	e,f	1.0	1.0	..	1.0	..	..	..	..	0.9	..	..	..	..
Unimproved farmland	e,f	28.0	26.7	..	25.0	..	..	..	..	24.2	..	..	..	..
Total farmland	e,f	69.8	70.5	..	68.7	..	..	..	..	68.4	..	..	..	..
Proportion of Canada's land area in agriculture (%)	d	7.6	7.6	..	7.5	..	..	..	..	7.4	..	..	..	..
Grain crop production (all types) (thousand tonnes)	f	15 961	36 784	25 863	35 892	32 938	33 799	28 205	33 441	40 931	37 947	37 342	30 643	35 564
Total cattle inventory (thousands)[4]	f	11 934	12 879	12 826	13 271	13 644	14 128	15 101	15 260	14 384	13 619	12 807	12 650	12 764
Agricultural fertilizer use (thousand tonnes)														
Nitrogen	g	73	218	268	323	334	410	513	531	586	599	755	831	831
Phosphate	g	161	333	281	326	341	415	494	502	503	503	594	630	628
Potash	g	93	142	175	184	189	191	202	207	242	234	273	330	349
Total fertilizer sold (thousand tonnes)[5]	g	709	1 811	1 694	1 915	1 972	2 261	2 608	2 676	2 780	2 829	3 267	3 671	3 572
Value of agricultural pesticides applied (million $1986)	e	..	..	169	..	..	..	..	..	..	..	..	..	398
Proportion of Canada's land area in forests (%)	d,h	..	..	..	..	..	..	..	..	..	..	..	..	47
Forest harvested (thousand cubic metres)	c	..	..	121 400	..	..	..	..	..	..	..	..	..	156 500
Natural loss of forests (thousand cubic metres)	c	..	..	..	..	..	..	..	..	..	..	..	..	24 600
Total forest depletion (thousand cubic metres)	c	..	..	...	..	..	..	..	..	..	..	..	..	181 100
Rural to urban land conversion (hectares)[6]	i	..	..	..	86 090	..	..	..	..	61 164	..	..	..	..
ATLANTIC FISH CATCH[7] (thousand tonnes)														
Groundfish	j	1 365	1 743	1 738	1 701	1 627	1 646	1 359	1 195	998	820	848	934	930
Pelagics	j	85	285	784	824	787	935	871	916	829	533	326	236	242
Salmon	j	2	4	4	5	4	5	4	5	4	4	3	3	4
Total finfish	j	1 452	2 032	2 526	2 530	2 418	2 586	2 234	2 116	1 831	1 357	1 177	1 173	1 176
ENERGY USE (petajoules)														
Coal	k,d	548	635	708	673	635	654	665	658	709	773	789	876	928
Oil	d	1 803	2 328	2 860	3 119	3 425	3 771	3 931	3 806	3 770	4 004	4 011	4 297	4 196
Natural gas	d	566	938	1 370	1 462	1 644	1 749	1 767	1 800	1 841	1 643	1 664	1 734	1 785
Natural gas liquids	d	13	43	49	56	66	69	83	74	71	56	48	69	86
Total primary fuels	d	3 294	4 408	5 545	5 890	6 411	6 937	7 209	7 081	7 183	7 296	7 389	7 864	7 929
Nuclear	d,e	...	1	4	15	26	54	53	45	63	95	112	127	137
Total non-renewable energy	d	6 224	8 353	10 536	11 215	12 208	13 235	13 708	13 463	13 637	13 866	14 013	14 967	15 062
Hydroelectricity	d,e	364	463	555	564	615	641	709	699	729	725	766	761	797
Wood	k	178	107	106	342	353	377	391	326	346	346	357	374	405
Total renewable energy	d	542	570	661	906	968	1 018	1 100	1 025	1 075	1 071	1 123	1 135	1 202
Total energy	d	6 766	8 923	11 197	12 121	13 176	14 252	14 808	14 487	14 712	14 937	15 136	16 102	16 264
Energy per capita (gigajoules per capita)	d	180	220	260	267	288	308	315	305	305	307	307	324	322
Energy per $ of real GDP (megajoules per 1986 $)	d	19.5	19.0	20.4	20.5	21.1	21.2	21.1	20.2	19.3	18.9	18.3	18.8	18.7

Notes:
1. This information provides a measure of the number of times the oxides, ozone or particulates exceeded maximum acceptable levels each year.
2. From 1961 to 1992 figures are averaged from six readings per year while 1993 figures are averaged from three readings.
3. Dobson unit: a unit measure used to estimate the thickness of the ozone layer. 100 Dobson units represents a quantity equivalent to a 1mm thick layer of ozone at sea level.
4. Changes in surveying dates and methods between 1975 and 1976 may cause some inconsistencies.
5. Total fertilizer sold includes all nutrients as well as fertilizer filler materials.
6. These figures represent rural to urban land use conversion over the preceding five years. Data were not collected after 1986.
7. Includes surveillance estimates of catches in the NAFO regulatory area and foreign catches made outside the 200-mile zone on straddling stocks and the Flemish Cap.

Sources:
a. Environment Canada, State of the Environment Directorate, ***Technical Supplement to the Environmental Indicator Bulletin on Urban Air Quality***, Ottawa, 1994.
b. Environment Canada, State of the Environment Directorate, ***Technical Supplement to the Environmental Indicator Bulletin on Stratospheric Ozone Depletion***, Ottawa, 1993.
c. Organisation for Economic Cooperation and Development, ***OECD Environmental Data Compendium 1993***, Paris, 1993.
d. Statistics Canada, National Accounts and Environment Division.
e. Statistics Canada, ***Human Activity and the Environment 1994***, Cat. No. 11-509, Ottawa, 1994.
f. Statistics Canada, Agriculture Division.
g. Statistics Canada, ***Fertilizer Trade***, Cat. No. 46-207, Ottawa, various issues, and Agriculture Canada, Farm Policy Development Branch.
h. Natural Resources Canada, Canadian Forest Service, Canada's Forest Inventory 1981, 1986, 1991.
i. Environment Canada, State of Environment Directorate, ***Technical Supplement to a Report on Canada's Progress Towards a National Set of Environmental Indicators***, Ottawa, 1991.
j. Department of Fisheries and Oceans Canada, Biological Sciences Directorate.
k. Environment Canada, State of the Environment Directorate, ***Technical Supplement to the Environmental Indicator Bulletin on Energy Consumption***, Ottawa, 1994.

Table 1

Selected Environmental Quality Statistics, 1961-1994 (Concluded)

	Source	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
AIR QUALITY															
Urban ground level[1]															
Average station exceedances for SO_2, NO_x and CO	a	10.3	6.8	5.4	2.2	2.6	4.4	1.8	2.5	1.3	3.3	1.0	0.2	..	..
Average station exceedances for ozone	a	23.8	13.8	35.6	17.9	11.6	10.0	15.8	57.8	19.8	10.6	19.0	6.7	..	..
Average station exceedances for particulates	a	5.8	4.4	2.7	3.1	2.0	2.0	2.5	2.4	1.9	0.9	1.1	0.8	..	..
Ozone layer[2] (Dobson units[3])															
Toronto	b	347	341	337	337	338	339	341	341	338	337	335	332	326	..
Edmonton	b	342	341	338	336	335	335	335	333	332	332	330	324	319	..
Resolute	b	376	372	367	370	375	366	357	354	350	349	349	345	337	..
Production of CFCs (kt)	b	15.2	14.2	15.6	16.9	18.5	19.9	21.2	21.0	18.8	13.1	8.8	10.7	..	..
Production of other ozone depleting substances (kt)	b	2.8	3.2	3.7	4.7	4.6	5.0	6.6	6.6	5.4	4.1	3.5	2.5	..	..
Air emissions (thousand tonnes)															
Nitrogen dioxide	c	1 907	1 897	1 884	1 871	1 958	..	..	..	..	1 923	..	..	..	..
Sulphur dioxide	c	4 291	3 612	3 625	3 955	3 692	3 627	3 762	3 838	3 695	3 323	3 306	..	..	..
Carbon monoxide	c	..	..	..	..	10 781	..	..	..	..	..	..	..	..	..
Carbon dioxide from fossil fuel combustion	d	410	390	381	396	412	404	419	450	465	445	437	452	453	..
Particulates	c	..	..	..	..	1 709	..	..	..	..	..	..	..	..	..
LAND															
Agricultural land use (million hectares)															
Cropland	e,f	30.9	..	..	..	..	33.2	..	..	..	..	33.5	..	..	..
Improved pasture	e,f	4.1	..	..	..	..	3.6	..	..	..	..	4.1	..	..	..
Summerfallow	e,f	9.7	..	..	..	..	8.5	..	..	..	..	7.9	..	..	..
Other land	e,f	1.4	..	..	..	..	0.7	..	..	..	..	..	..	..	..
Unimproved farmland	e,f	19.8	..	..	..	..	21.8	..	..	..	..	..	..	..	..
Total farmland	e,f	65.9	..	..	..	..	67.8	..	..	..	..	67.8	..	..	..
Proportion of Canada's land area in agriculture (%)	d	7.2	..	..	..	..	7.4	..	..	..	..	7.4	..	..	..
Grain crop production (all types) (thousand tonnes)	f	44 096	46 728	41 415	35 933	41 209	50 870	44 477	30 250	41 881	49 530	46 314	44 605	45 802	..
Total cattle inventory (thousands)[4]	f	12 764	12 591	12 290	12 031	11 651	11 299	11 264	11 512	11 780	11 907	12 172	12 473	12 715	13 263
Agricultural fertilizer use (thousand tonnes)															
Nitrogen	g	916	966	1 002	1 157	1 254	1 221	1 145	1 188	1 160	1 196	1 158	1 253	1 306	1 406
Phosphate	g	635	636	652	713	724	695	626	634	614	614	578	592	637	616
Potash	g	363	344	338	377	400	370	370	404	356	360	338	310	328	316
Total fertilizer sold (thousand tonnes)[5]	g	3 758	3 742	3 842	4 243	4 435	4 300	4 069	4 241	4 048	4 105	3 922	4 071	4 218	4 501
Value of agricultural pesticides applied (million $1986)	e	..	..	..	..	694	..	..	..	..	705	..	..	..	..
Proportion of Canada's land area in forests (%)	d,h	..	..	..	..	48	..	..	..	..	..	45	..	..	..
Forest harvested (thousand cubic metres)	c	..	..	..	..	143 700	..	..	..	..	188 000	..	..	..	..
Natural loss of forests (thousand cubic metres)	c	..	..	..	..	143 800	..	..	..	..	217 000	..	..	..	..
Total forest depletion (thousand cubic metres)	c	..	..	..	..	287 500	..	..	..	..	405 000	..	..	..	..
Rural to urban land conversion (hectares)[6]	i	98 976	..	..	..	..	55 210	..	..	..	..	..	..	..	..
ATLANTIC FISH CATCH[7] (thousand tonnes)															
Groundfish	j	980	1 032	949	983	1 062	1 157	1 120	1 031	1 026	998	886	659 p	455 p	192 p
Pelagics	j	255	217	231	270	302	379	412	493	423	516	331	286 p	258 p	203 p
Salmon	j	4	3	2	1	2	3	3	2	1	1	1	1 p	- p	- p
Total finfish	j	1 239	1 252	1 182	1 254	1 366	1 539	1 535	1 526	1 450	1 515	1 218	946 p	713 p	395 p
ENERGY USE (petajoules)															
Coal	k,d	946	1 002	1 048	1 167	1 122	1 040	1 118	1 200	1 198	1 077	1 104	1 137	1 044	..
Oil	d	3 990	3 332	3 183	3 170	3 077	3 038	3 155	3 339	3 402	3 463	3 249	3 175	3 462	..
Natural gas	d	1 710	1 718	1 754	1 880	2 361	2 317	2 358	2 593	2 790	2 676	2 705	2 863	2 439	..
Natural gas liquids	d	104	73	93	136	172	164	216	217	236	217	232	262	275	..
Total primary fuels	d	7 713	7 062	7 061	7 412	7 876	7 789	8 082	8 627	8 902	8 738	8 612	8 748	8 873	..
Nuclear	d,e	136	130	166	177	206	242	262	281	271	248	288	274	319	..
Total non-renewable energy	d	14 599	13 317	13 305	13 942	14 813	14 590	15 191	16 257	16 798	16 419	16 191	16 458	16 412	..
Hydroelectricity	d,e	826	806	817	881	939	989	972	996	1 005	1 057	1 033	1 038	1 055	..
Wood	k	393	421	459	391	473	498	503	503	483	473	485	491	493	..
Total renewable energy	d	1 219	1 227	1 276	1 272	1 412	1 487	1 475	1 499	1 488	1 530	1 518	1 529	1 548	..
Total energy	d	15 818	14 544	14 581	15 214	16 225	16 077	16 666	17 756	18 286	17 949	17 709	17 987	17 960	..
Energy per capita (gigajoules per capita)	d	310	280	277	288	304	297	304	321	325	314	306	308	314	..
Energy per $ of real GDP (megajoules per 1986 $)	d	17.5	16.6	16.1	15.9	16.1	15.4	15.4	15.7	15.7	15.4	15.5	15.6	15.9	..

Notes:

1. This information provides a measure of the number of times the oxides, ozone or particulates exceeded maximum acceptable levels each year.
2. From 1961 to 1992 figures are averaged from six readings per year while 1993 figures are averaged from three readings.
3. Dobson unit: a unit measure used to estimate the thickness of the ozone layer. 100 Dobson units represents a quantity equivalent to a 1mm thick layer of ozone at sea level.
4. Changes in surveying dates and methods between 1975 and 1976 may cause some inconsistencies.
5. Total fertilizer sold includes all nutrients as well as fertilizer filler materials.
6. These figures represent rural to urban land use conversion over the preceding five years. Data were not collected after 1986.
7. Includes surveillance estimates of catches in the NAFO regulatory area and foreign catches made outside the 200-mile zone on straddling stocks and the Flemish Cap.

Sources:

a. Environment Canada, State of the Environment Directorate, ***Technical Supplement to the Environmental Indicator Bulletin on Urban Air Quality***, Ottawa, 1994.
b. Environment Canada, State of the Environment Directorate, ***Technical Supplement to the Environmental Indicator Bulletin on Stratospheric Ozone Depletion***, Ottawa, 1993.
c. Organisation for Economic Cooperation and Development, ***OECD Environmental Data Compendium 1993***, Paris, 1993.
d. Statistics Canada, National Accounts and Environment Division.
e. Statistics Canada, ***Human Activity and the Environment 1994***, Cat. No. 11-509, Ottawa, 1994.
f. Statistics Canada, Agriculture Division.
g. Statistics Canada, ***Fertilizer Trade***, Cat. No. 46-207, Ottawa, various issues, and Agriculture Canada, Farm Policy Development Branch.
h. Natural Resources Canada, Canadian Forest Service, Canada's Forest Inventory 1981, 1986, 1991.
i. Environment Canada, State of Environment Directorate, ***Technical Supplement to a Report on Canada's Progress Towards a National Set of Environmental Indicators***, Ottawa, 1991.
j. Department of Fisheries and Oceans Canada, Biological Sciences Directorate.
k. Environment Canada, State of the Environment Directorate, ***Technical Supplement to the Environmental Indicator Bulletin on Energy Consumption***, Ottawa, 1994.

Table 2
Selected Water Quality Statistics, 1970-1992

	Source	1970	1975	1980	1983	1985	1986	1989	1991	1992
Surface water quality										
Nitrate(mg/litre)										
St. Lawrence River	a	0.193	0.230	0.160	..	0.200	..	0.420	..	..
Saskatchewan River	a	..	0.150	0.100	..	0.160	..	0.120	..	..
Phosphorus(mg/litre)										
St. Lawrence River	a	0.018	0.010	0.025	..	0.018	..	..	0.020	..
Saskatchewan River	a	..	0.049	0.064	..	0.070	..	..	0.032	..
Dissolved oxygen(mg/litre)										
St. Lawrence River	a	8.100	10.000	..	..	9.400	..	..	..	..
Saskatchewan River	a	..	10.000	10.800	..	10.400	..	..	10.000	..
Population served by municipal wastewater treatment (% of total population)										
No treatment	b	..	..	..	28	..	28	19	..	16
Some treatment	b	..	..	..	72	..	72	80	..	84
Primary treatment	b	..	..	..	16	..	15	20	..	20
Secondary treatment	b	..	..	..	28	..	26	28	..	27
Tertiary treatment	b	..	..	..	28	..	31	32	..	37

Note:
Figures may not add due to rounding.
Sources:
a. National Center for Economic Alternatives, ***Index of Environmental Trends***, Washington, 1995.
b. Environment Canada, Municipal Water Use Database (MUD).

Table 3
Selected Statistics on Land by Province and Territory, 1986-1993

	Year	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Total area (km^2)		a	9 970 610	405 720	5 660	55 490	73 440	1 540 680	1 068 580	649 950	652 330	661 190	947 800	483 450	3 426 320
Water area (km^2)		a	755 180	34 030	--	2 650	1 350	183 890	177 390	101 590	81 630	16 800	18 070	4 480	133 300
Land area (km^2)		a	9 215 430	371 690	5 660	52 840	72 090	1 356 790	891 190	548 360	570 700	644 390	929 730	478 970	3 293 020
Area of farms (km^2)	1986	a	678 258	366	2 724	4 165	4 089	36 388	56 466	77 402	265 994	206 553	24 111	-	-
	1991	a	677 537	474	2 589	3 970	3 756	34 296	54 514	77 250	268 655	208 110	23 923	-	-
Forest land[1] (km^2)	1986	c	4 533 200	224 800	2 900	40 400	63 400	940 000	807 000	349 200	237 100	377 500	603 100	273 700	616 000
	1991	d	4 161 770	225 250	2 950	39 230	61 060	824 860	579 950	262 770	288 060	382 140	605 640	275 500	614 360
Other land (km^2)	1986	c	4 003 972	146 524	36	8 275	4 601	380 402	27 724	121 758	67 606	60 337	302 519	205 270	2 677 020
	1991	d	4 376 123	145 966	121	9 640	7 274	497 634	256 726	208 340	13 985	54 140	300 167	203 470	2 678 660
Use of farmland															
Cropland (km^2)	1986	a	331 812	49	1 565	1 095	1 295	17 444	34 580	45 193	133 258	91 625	5 708	-	-
	1991	a	335 078	63	1 541	1 062	1 222	16 385	34 117	47 610	134 589	92 920	5 568	-	-
Improved pasture (km^2)	1986	a	35 592	38	226	362	272	3 011	4 313	2 749	8 787	13 768	2 064	-	-
	1991	a	41 412	46	193	307	250	2 709	3 902	3 413	10 757	17 425	2 410	-	-
Summerfallow (km^2)	1986	a	84 990	4	26	39	43	318	803	5 092	56 583	21 270	812	-	-
	1991	a	79 209	1	10	12	16	147	637	2 970	57 128	17 714	575	-	-
Cropland tilled[2] (percent)	1991	b	80.9	97.7	99.4	98.9	98.7	99.1	98.2	94.1	70.2	84.0	90.6	-	-
Protected area (km^2)	1993	e	774 451	7 617	333	3 187	3 935	164 909	77 008	48 957	17 030	66 519	103 140	49 452	232 364
Road network															
Two-lane equivalent length[3] (km)	1990-91	f	874 155	12 290	4 935	25 779	20 670	119 321	167 500	84 965	193 923	173 473	62 158	5 238	3 903
Density (km/thousand km^2)	1990-91	f	95	33	872	488	287	88	188	155	340	269	67	11	1

Notes:
Figures may not add due to rounding.
1. Values in 1986 include estimates of non-inventoried forest land.
2. Cropland in this definition excludes no-till and permanent cropland areas such as tree fruit orchards.
3. Canada figures includes 14 743 km under federal jurisdiction.
Sources:
a. Statistics Canada, ***Canada Year Book 1994***, Cat. No. 11-402, Ottawa, 1994.
b. Statistics Canada, National Accounts and Environment Division.
c. Natural Resources Canada, ***Canada's Forest Inventory, 1986***, Ottawa, 1987.
d. Natural Resources Canada, Canadian Forest Service, Canadian Council of Forest Ministers, ***Compendium of Canadian Forestry Statistics 1993***, Ottawa, 1994.
*e. **Environment Canada, State of the Environment Directorate, National Conservation Areas Database, 1993**.*
*f. **Transportation Association of Canada**.*

Table 4

Selected Statistics on Forestry by Province and Territory, 1986-1992

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon[1]	N.W.T.[1]
Total production[2] (million $)													
1986	5 775.5	95.4	0.6	147.2	365.3	1 096.4	1 015.0	53.7	91.4	114.2	2 796.2	--	..
1987	7 538.3	107.7	--	173.5	439.1	1 441.4	1 146.9	74.7	107.3	138.8	3 907.3	--	..
1988	8 061.9	122.1	1.5	203.9	546.8	1 540.3	1 201.0	68.7	119.1	152.7	4 105.5	0.6	..
1989	8 696.8	132.0	2.0	203.9	603.4	1 732.9	1 290.5	72.9	122.4	183.9	4 351.7	1.4	..
1990	8 113.8	135.9	2.6	196.2	557.9	1 649.3	1 168.4	78.9	102.6	203.4	4 017.7	0.9	..
1991	7 702.0	132.6	3.3	198.2	492.2	1 520.6	1 092.6	61.7	78.3	273.4	3 848.5	0.6	..
1992	8 358.5	128.4	1.7	220.1	475.1	1 580.7	1 188.3	76.3	99.3	293.9	4 294.3	0.6	..
Total roundwood harvested (thousand cubic metres)													
1986	177 190	2 408	424	4 004	8 720	38 127	30 186	1 703	3 529	10 387	77 503	199	..
1987	191 684	2 524	479	4 789	7 869	39 503	29 692	1 887	3 666	10 496	90 591	188	..
1988	190 615	2 513	475	5 039	9 199	39 381	29 338	1 883	3 818	11 990	86 807	172	..
1989	188 254	2 535	416	4 772	9 281	36 192	29 642	1 848	3 685	12 293	87 414	176	..
1990	162 947	2 876	448	4 639	8 824	30 524	25 421	1 563	2 758	11 911	73 861	82	40
1991	161 511	2 680	452	4 322	8 643	29 595	23 828	1 278	2 957	12 926	74 706	79	47
1992	170 306	2 821	510	4 248	9 205	31 171	24 287	1 598	3 081	14 594	78 579	162	50
Area harvested (hectares)[3]													
1986	971 813	17 440	2 350	34 121	86 898	297 616	223 517	11 128	19 356	38 811	239 877	299	400
1987	1 050 850	18 940	2 725	42 266	88 976	329 300	228 464	12 362	25 742	40 248	259 982	1 172	672
1988	1 086 100	19 628	2 731	41 421	99 192	337 668	237 188	12 378	22 089	42 538	270 401	465	399
1989	1 017 820	19 449	2 421	36 733	90 144	342 231	230 308	12 205	22 281	41 688	218 384	1 554	450
1990	920 827	22 100	2 317	39 310	80 109	282 470	238 213	10 349	16 538	47 200	181 530	366	325
1991	857 162	20 584	2 091	37 566	91 916	236 815	199 719	8 518	17 522	47 960	192 654	350	467
1992	933 177	18 931	2 550	33 932	103 355	283 124	190 677	11 414	18 471	48 100	221 599	639	405
Area burned - stocked timber-productive forest land[3] (hectares)													
1986	311 367	23 511	85	268	37 216	173 296	50 598	5 495	4 031	1 587	9 474	3 132	11
1987	306 516	10 622	16	312	895	27 849	5 461	84 266	129 332	24 295	22 308	1 150	10
1988	639 777	7	2	89	1 778	273 066	35 994	295 930	24 187	5 149	3 284	288	3
1989	3 877 390	2 651	2	159	280	2 108 210	4 990	1 539 180	137 404	2 994	11 089	70 439	..
1990	281 831	2 601	4	477	5 198	76 825	3 200	6 727	71 198	21 281	52 575	16 704	..
1991	375 131	9 576	23	1 022	2 732	101 306	5 025	55 266	118 849	2 222	16 658	61 228	..
1992	..	1 015	8	805	4 668	24 298	10 331	187 890	12 798	1 006	..	3 785	..
Area seeded and planted (hectares)													
1986	334 918	802	863	9 160	20 517	64 888	94 782	4 146	4 482	19 539	115 739	-	-
1987	430 456	5 604	1 092	9 880	18 916	92 437	101 468	5 721	3 110	23 226	169 002	-	-
1988	459 865	4 468	1 077	11 655	19 123	99 880	111 251	7 061	7 020	28 845	169 485	-	-
1989	476 440	4 691	744	9 760	20 272	103 230	118 256	8 264	6 106	30 807	174 310	-	-
1990	508 608	3 548	833	11 255	22 148	104 369	107 861	6 282	6 012	37 052	209 168	80	..
1991	505 689	2 891	1 032	8 198	19 529	99 590	120 627	8 041	6 545	39 775	199 422	39	..
1992	463 364	3 531	1 161	7 502	16 526	96 897	96 259	7 142	6 404	42 973	184 922	45	2

Notes:

One square kilometre contains 100 hectares.

1. Data for Northwest Territories included in data for Yukon when not available separately.
2. Total production is the value of shipments of the logging industry.
3. Canada total includes areas burned in National Parks.

Sources:

Statistics Canada, ***Canadian Forestry Statistics***, Cat. No. 25-202, Ottawa, various issues.

Natural Resources Canada, Canadian Forests Service, Canadian Council of Forest Ministers, ***Compendium of Canadian Forestry Statistics 1993***, Ottawa, 1993.

Table 5

Nominal Catches and Landed Values of Fish by Species and Region, 1992-1993

Species	1992[1]						1993[1]					
	Atlantic coast		Pacific coast		**Canada**		Atlantic coast		Pacific coast		**Canada**	
	Quantity[2]	Value	Quantity[2]	Value	**Quantity[2]**	**Value**	Quantity[2]	Value	Quantity[2]	Value	**Quantity[2]**	**Value**
	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**
Groundfish												
Cod[3]	186 522	152 023	10 111	5 519	**196 633**	**157 542**	71 889	59 936	7 700	4 377	**79 589**	**64 313**
Haddock	21 947	30 204	-	-	**21 947**	**30 204**	13 131	20 997	-	-	**13 131**	**20 997**
Redfish	97 990	27 706	24 752	18 252	**122 742**	**45 958**	77 734	21 070	22 527	16 031	**100 261**	**37 101**
Halibut	1 573	7 233	4 289	20 206	**5 862**	**27 439**	1 482	6 979	5 688	27 000	**7 170**	**33 979**
Flatfishes	48 500	29 245	7 802	5 728	**56 302**	**34 973**	38 597	23 659	9 341	6 712	**47 938**	**30 371**
Turbot	22 454	19 255	3 545	863	**25 999**	**20 118**	18 909	16 153	3 932	1 002	**22 841**	**17 155**
Pollock	34 056	24 007	3 006	911	**37 062**	**24 918**	21 970	12 370	5 744	1 877	**27 714**	**14 247**
Hake[4]	38 293	17 735	97 197	16 025	**135 490**	**33 760**	35 388	22 146	62 509	8 664	**97 897**	**30 810**
Cusk	5 077	4 271	-	-	**5 077**	**4 271**	2 948	2 347	-	-	**2 948**	**2 347**
Catfish	1 282	385	-	-	**1 282**	**385**	1 003	283	-	-	**1 003**	**283**
Other	3 641	1 687	8 954	26 339	**12 595**	**28 026**	3 583	1 281	9 127	23 325	**12 710**	**24 606**
Total	**461 335**	**313 751**	**159 656**	**93 843**	**620 991**	**407 594**	**286 634**	**187 221**	**126 568**	**88 988**	**413 202**	**276 209**
Pelagic and other finfish												
Herring	215 384	27 799	34 531	46 369	**249 915**	**74 168**	194 126	24 572	40 669	67 999	**234 795**	**92 571**
Mackerel	25 874	7 070	-	-	**25 874**	**7 070**	26 124	7 208	-	-	**26 124**	**7 208**
Tuna	494	7 468	309	789	**803**	**8 257**	524	5 678	322	755	**846**	**6 433**
Alewife	3 441	2 237	-	-	**3 441**	**2 237**	5 680	1 306	-	-	**5 680**	**1 306**
Eel	742	1 990	-	-	**742**	**1 990**	393	1 650	-	-	**393**	**1 650**
Salmon	283	1 095	64 856	161 284	**65 139**	**162 379**	134	625	81 743	189 338	**81 877**	**189 963**
Skate	491	78	259	52	**750**	**130**	293	47	224	38	**517**	**85**
Smelt	874	775	1	2	**875**	**777**	889	923	1	3	**890**	**926**
Capelin	30 966	4 813	-	-	**30 966**	**4 813**	47 441	13 409	-	-	**47 441**	**13 409**
Other	4 001	13 936	3 348	1 800	**7 349**	**15 736**	5 427	18 739	886	797	**6 313**	**13 409**
Total	**282 550**	**67 261**	**103 304**	**210 296**	**385 854**	**277 557**	**281 031**	**74 157**	**123 845**	**258 930**	**404 876**	**326 960**
Shellfish												
Clams	16 804	15 360	4 033	18 623	**20 837**	**33 983**	24 081	24 530	3 582	27 980	**27 663**	**52 510**
Oysters	600	992	5 000	4 000	**5 600**	**4 992**	621	1 193	5 250	4 200	**5 871**	**5 393**
Scallop	91 315	99 646	-	-	**91 315**	**99 646**	88 586	115 718	-	-	**88 586**	**115 718**
Squid	1 352	366	-	-	**1 352**	**366**	2 701	568	-	-	**2 701**	**568**
Lobster	41 560	313 968	-	-	**41 560**	**313 968**	40 098	293 718	-	-	**40 098**	**293 718**
Shrimps	39 241	81 241	3 505	10 864	**42 746**	**92 105**	38 037	81 299	4 262	12 140	**42 299**	**93 439**
Crab	37 861	58 817	2 492	9 336	**40 353**	**68 153**	62 611	112 544	6 242	18 550	**68 853**	**131 094**
Other	4 340	4 580	13 831	14 130	**18 171**	**18 710**	3 295	5 025	7 454	10 615	**10 749**	**15 640**
Total	**233 073**	**574 970**	**28 861**	**56 953**	**261 934**	**631 923**	**260 030**	**634 595**	**26 790**	**73 485**	**286 820**	**708 080**
Miscellaneous items[5]	**...**	**10 530**	**...**	**8 230**	**...**	**18 760**	**17 931**	**6 271**	**200**	**1 060**	**18 131**	**7 331**
Total sea fisheries	**976 958**	**966 512**	**291 821**	**369 322**	**1 268 779**	**1 335 834**	**845 626**	**902 244**	**277 403**	**422 463**	**1 123 029**	**1 318 580**
Total inland fisheries	**...**	**...**	**...**	**...**	**64 907**	**63 000**	**...**	**...**	**...**	**...**	**...**	**...**
Grand total	**976 958**	**966 512**	**291 821**	**369 322**	**1 333 686**	**1 398 834**	**845 626**	**902 244**	**277 403**	**422 463**	**1 123 029**	**1 318 580**

Notes:
1. Preliminary data.
2. Quantity in tonnes, live weight.
3. Pacific cod includes grey cod only.
4. Hake catches include over-the-side sales to foreign vessels.
5. Contains marine plants and lumpfish roe. May contain other miscellaneous items.

Source:
Department of Fisheries and Oceans Canada, Biological Sciences and Industry Development and Programs Directorate.

Table 6

Reserves of Crude Oil and Natural Gas by Province and Territory, December 31, 1986-1993

	Year	Canada	Eastern Canada	Eastcoast offshore	Ont.	Man.	Sask.	Alta.	B.C.	Mainland territories	Mackenzie Delta/ Beaufort Sea	Arctic Islands
Crude oil (thousand cubic metres)												
	1986	944 411	2	83 000	904	10 522	106 296	632 743	18 500	27 460	64 950	34
	1987	940 162	2	83 000	794	10 485	106 146	631 315	17 013	26 358	64 950	99
	1988	975 148	5	133 000	1 311	8 838	112 838	611 518	17 934	24 610	64 950	144
	1989	937 993	5	138 600	1 324	8 349	111 909	582 531	18 490	22 734	53 950	101
	1990	887 957	5	138 600	1 414	8 351	116 896	530 205	17 566	20 893	53 950	77
	1991	841 302	5	138 600	1 323	7 806	110 336	489 959	17 662	21 609	53 950	52
	1992	809 734	5	138 020	1 224	7 144	119 515	452 143	17 911	19 748	53 950	74
	1993	800 586	5	137 017	1 169	6 534	131 213	435 003	17 549	17 979	53 950	167
Natural gas (million cubic metres)												
	1986	2 745 510	141	-	17 444	-	61 305	1 749 997	240 307	11 636	258 310	406 370
	1987	2 692 783	125	-	17 949	-	60 705	1 727 725	210 327	11 272	258 310	406 370
	1988	2 670 545	98	-	18 311	-	56 283	1 688 054	210 094	11 205	280 130	406 370
	1989	2 732 449	90	-	17 529	-	74 791	1 705 559	218 393	10 987	298 730	406 370
	1990	2 725 390	72	-	16 903	-	78 880	1 689 884	223 638	10 913	298 730	406 370
	1991	2 710 869	72	-	16 718	-	71 182	1 678 553	229 215	10 029	298 730	406 370
	1992	2 671 554	71	-	16 881	-	70 409	1 621 875	247 335	9 883	298 730	406 370
	1993	2 232 256	111	-	17 217	-	80 927	1 578 959	246 957	9 355	298 730	- [1]

Notes:
Figures may not add due to rounding.
1. Reserves of crude oil in the Arctic Islands are no longer considered as economically recoverable.
Source:
Canadian Petroleum Association, ***Statistical Handbook***, Calgary, various issues.

Table 7

Quantity of Production of Crude Oil and Natural Gas by Province and Territory, 1986-1993

	Year	Canada	Eastern Canada	Eastcoast offshore	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.[1]
Crude oil (thousand cubic metres)											
	1986	69 226	--	-	136	823	11 688	53 082	2 020	-	1 478
	1987	71 823	--	4	136	782	12 078	55 170	2 084	-	1 570
	1988	74 495	-	-	191	769	12 168	57 653	1 882	-	1 833
	1989	70 977	-	-	244	723	11 633	54 605	1 888	-	1 884
	1990	70 179	-	-	247	738	12 431	52 973	1 926	-	1 864
	1991	69 362	-	-	235	713	12 390	52 085	2 013	-	1 927
	1992	71 898	-	576	224	656	13 355	53 175	2 033	-	1 878
	1993	75 233	-	1 016	253	635	14 939	54 548	2 004	-	1 838
Natural gas (million cubic metres)											
	1986	91 667	1	-	504	-	2 204	80 303	8 374	-	282
	1987	99 490	1	-	508	-	2 751	86 259	9 724	-	249
	1988	114 135	-	-	509	-	4 156	98 577	10 687	-	205
	1989	118 706	-	-	492	-	5 506	99 747	12 788	-	171
	1990	121 696	-	-	449	-	6 552	102 748	11 800	-	147
	1991	129 596	-	-	428	-	7 172	106 851	14 712	-	434
	1992	143 205	-	-	427	-	7 030	118 895	16 134	506	213
	1993	155 030	-	-	411	-	7 372	129 129	17 399	491	228

Notes:
Figures may not add due to rounding.
1. From 1986 to 1991, production data for the Yukon and N.W.T. are reported together under the N.W.T.
Source:
Statistics Canada, ***The Crude Petroleum and Natural Gas Industry***, Cat. No. 26-213, Ottawa, various issues.

Table 8

Selected Metal Reserves by Province and Territory, December 31, 1986-1992

	Year	Canada	Nfld.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Copper (thousand tonnes)													
	1986	13 331	-	62	330	623	6 260	492	5	-	5 560	-	-
	1987	12 939	-	62	311	806	6 103	475	5	-	5 177	-	-
	1988	12 693	-	34	302	838	5 866	515	5	-	5 133	-	-
	1989	12 258	-	21	471	844	5 514	519	2	-	4 889	-	-
	1990	11 203	-	11	375	775	5 050	538	-	-	4 454	-	-
	1991	11 115	-	-	238	1 601	4 695	422	3	-	4 156	-	-
	1992	10 818	-	-	234	1 503	4 960	421	-	-	3 699	-	-
Nickel (thousand tonnes)													
	1986	6 704	-	-	-	-	4 908	1 796	-	-	-	-	-
	1987	6 605	-	-	-	-	4 822	1 784	-	-	-	-	-
	1988	6 279	-	-	-	-	4 546	1 733	-	-	-	-	-
	1989	6 132	-	-	-	-	4 461	1 672	-	-	-	-	-
	1990	5 792	-	-	-	-	4 208	1 584	-	-	-	-	-
	1991	5 691	-	-	-	-	4 162	1 529	-	-	-	-	-
	1992	5 605	-	-	-	-	4 160	1 445	-	-	-	-	-
Lead (thousand tonnes)													
	1986	7 167	-	-	3 648	-	133	25	--	-	1 256	1 275	831
	1987	6 694	-	-	3 551	-	104	25	--	-	1 180	1 212	621
	1988	6 969	-	-	3 482	-	101	20	-	-	1 071	1 755	540
	1989	6 941	-	68	3 839	9	100	17	-	-	999	1 404	506
	1990	6 317	-	29	3 383	28	94	13	-	-	957	1 358	456
	1991	4 954	-	-	2 463	23	63	9	-	-	908	1 093	397
	1992	4 348	-	-	2 264	20	53	11	-	-	786	856	358
Zinc (thousand tonnes)													
	1986	22 423	58	104	8 964	987	3 972	641	1	-	2 516	1 958	3 222
	1987	20 636	95	104	8 736	897	3 454	612	1	-	2 435	1 765	2 538
	1988	21 116	36	60	8 575	836	3 265	1 016	2	-	2 270	2 816	2 239
	1989	21 688	16	160	9 704	1 414	2 999	1 084	1	-	1 934	2 250	2 126
	1990	20 091	-	76	8 700	1 224	2 689	1 145	-	-	1 942	2 419	1 897
	1991	16 448	-	-	6 156	1 732	2 213	887	4	-	1 889	1 957	1 609
	1992	15 067	-	-	5 738	1 710	1 819	938	-	-	1 835	1 502	1 524
Silver (tonnes)													
	1986	26 694	-	-	9 759	1 506	6 893	721	2	-	5 838	1 849	126
	1987	25 648	-	-	9 699	1 501	6 057	729	2	-	5 621	1 896	143
	1988	26 959	-	-	9 933	1 200	5 802	812	3	-	6 140	2 943	127
	1989	26 790	4	-	10 761	1 620	5 504	787	1	-	5 624	2 349	141
	1990	23 227	4	-	9 498	1 311	5 027	757	1	-	4 162	2 339	127
	1991	19 069	2	-	7 003	2 074	4 422	654	3	-	2 838	1 953	121
	1992	16 300	3	-	6 456	2 008	4 106	398	-	-	2 098	1 119	113
Gold (tonnes)													
	1986	1 496	43	-	72	229	882	40	2	-	163	7	57
	1987	1 727	41	-	59	297	998	58	1	-	167	13	91
	1988	1 914	38	2	74	373	1 017	50	7	-	172	40	142
	1989	1 748	41	1	69	352	951	40	4	-	124	29	136
	1990	1 548	39	-	59	343	812	34	13	-	117	26	105
	1991	1 443	27	-	46	342	766	29	14	-	103	24	95
	1992	1 367	27	-	42	319	746	29	2	-	88	18	97

Note:
Figures may not add due to rounding.
Source:
Natural Resources Canada, ***Canadian Minerals Yearbook, Review and Outlook***, Ottawa, various issues.

Table 9

Production of Selected Metals by Province and Territory, 1986-1994

	Year	Canada	Nfld.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Copper (tonnes)	1986	698 527	-	-	6 298	51 622	264 870	65 369	3 506	-	306 855	6	1
	1987	794 149	-	x	7 233	66 848	287 354	66 121	2 335	-	364 134	x	2
	1988	758 478	-	-	7 966	47 633	286 536	53 072	2 168	-	360 570	x	1
	1989	704 432	-	x	7 802	65 135	271 914	50 484	x	-	308 348	-	-
	1990	771 433	-	x	8 620	99 198	273 448	55 506	x	-	333 883	-	-
	1991	780 362	-	x	10 476	113 931	261 899	54 875	x	-	338 642	-	-
	1992	761 694	-	-	13 697	91 950	272 242	60 024	-	-	323 781	-	-
	1993	709 650	231	-	11 190	78 973	277 461	56 502	-	-	285 293	-	-
	1994	583 271	600	-	7 566	65 597	225 066	40 863	-	-	243 579	-	-
Nickel (tonnes)	1986	163 639	-	-	-	-	121 851	41 788	-	-	-	-	-
	1987	189 086	-	-	-	-	130 171	58 915	-	-	-	-	-
	1988	198 744	-	-	-	-	128 558	70 186	-	-	-	-	-
	1989	195 554	-	-	-	-	130 632	64 922	-	-	-	-	-
	1990	195 004	-	-	-	-	128 828	66 176	-	-	-	-	-
	1991	188 098	-	-	-	-	125 790	62 309	-	-	-	-	-
	1992	177 555	-	-	-	-	118 860	58 695	-	-	-	-	-
	1993	178 529	-	-	-	-	125 833	52 696	-	-	-	-	-
	1994	144 323	-	-	-	-	113 648	30 675	-	-	-	-	-
Lead (tonnes)	1986	334 342	-	-	66 590	-	6 288	590	-	-	91 947	35 091	133 836
	1987	373 215	-	x	66 485	-	6 092	x	-	-	57 078	x	131 744
	1988	351 148	-	-	74 543	-	2 485	457	-	-	105 103	117 058	51 502
	1989	268 887	-	-	65 180	-	1 074	1 365	-	-	67 006	94 529	39 734
	1990	233 372	-	x	56 244	-	x	1 755	-	-	19 312	104 181	46 588
	1991	248 102	-	x	51 957	-	x	2 286	-	-	63 385	93 912	35 388
	1992	339 626	-	834	80 885	-	-	1 487	-	-	81 591	135 688	39 141
	1993	183 105	-	-	72 108	-	-	1 933	-	-	52 030	27 857	29 178
	1994	166 420	-	-	72 422	-	-	422	-	-	57 518	-	36 058
Zinc (tonnes)	1986	988 173	5 712	-	161 807	37 126	265 248	61 463	3 527	-	137 583	50 634	265 073
	1987	1 157 940	7 643	-	180 298	91 139	294 309	63 551	1 764	-	114 117	147 045	258 070
	1988	1 370 000	31 817	x	261 089	82 031	326 698	53 746	x	-	142 833	143 939	325 321
	1989	1 272 850	27 362	x	201 550	100 638	266 158	72 096	x	-	119 376	154 709	329 001
	1990	1 179 370	16 463	x	233 933	120 599	276 110	77 507	x	-	59 346	168 846	218 241
	1991	1 083 010	-	x	209 790	117 404	213 599	88 486	x	-	125 980	149 487	173 154
	1992	1 195 740	-	582	301 020	107 466	190 523	89 211	-	-	133 149	202 304	171 481
	1993	990 727	-	-	303 985	131 852	179 049	89 658	-	-	107 457	35 204	143 521
	1994	961 405	-	-	273 000	141 708	158 487	93 580	-	-	113 899	-	180 730
Silver (tonnes)	1986	1 088	-	-	163	62	348	37	3	--	380	73	22
	1987	1 475	-	--	182	163	441	41	2	--	401	133	13
	1988	1 443	x	x	203	140	434	32	x	-	447	159	26
	1989	1 312	x	x	191	148	349	36	x	-	498	71	18
	1990	1 381	x	x	145	164	330	41	x	-	598	84	19
	1991	1 261	x	x	158	164	294	43	x	-	497	87	17
	1992	1 169	x	--	254	143	248	40	x	-	345	124	16
	1993	879	x	-	223	143	232	38	x	-	201	30	11
	1994	708	x	-	211	134	191	38	x	-	116	1	17
Gold (kilograms)	1986	102 899	-	-	374	28 342	46 279	2 555	14	36	9 249	3 547	12 503
	1987	115 818	x	x	420	29 543	52 917	3 697	1 048	43	11 224	4 674	11 740
	1988	134 813	x	x	393	33 538	62 463	4 469	1 480	27	13 067	5 052	11 880
	1989	159 494	x	x	359	36 966	78 675	4 056	2 829	25	15 635	5 652	12 208
	1990	167 373	x	x	x	40 675	79 968	2 680	3 374	32	16 105	4 639	15 557
	1991	175 282	x	-	x	51 923	77 170	2 921	2 899	34	17 487	3 865	16 752
	1992	160 351	x	-	490	44 589	74 836	3 106	x	34	16 773	3 737	13 518
	1993	153 129	x	-	361	41 843	72 441	3 001	x	65	13 865	3 538	13 205
	1994	145 156	x	-	372	40 936	68 476	2 456	x	12	12 266	3 218	13 079

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, ***General Review of the Mineral Industries, Mines, Quarries and Oil Wells***, Cat. No. 26-201, Ottawa, various issues.
Statistics Canada, ***Canada's Mineral Production, Preliminary Estimates***, Cat. No. 26-202, Ottawa, various issues.

Table 10
Value of Mineral Production, 1986-1994

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
							million dollars						
1986	32 446	817	2	367	502	2 191	4 825	764	2 525	16 331	3 160	176	788
1987	36 361	743	3	407	624	2 780	5 652	1 000	3 151	17 080	3 615	437	870
1988	36 955	865	2	446	911	2 712	6 895	1 627	3 043	15 062	3 943	492	957
1989	39 333	897	2	442	859	2 878	7 308	1 668	3 017	16 456	4 123	534	1 149
1990	40 778	866	3	459	878	3 037	6 446	1 311	3 183	19 110	3 954	542	988
1991	35 190	772	3	460	671	2 930	5 101	1 125	2 863	16 373	3 840	349	703
1992	35 414	706	2	523	910	2 694	4 776	1 082	3 158	16 885	3 500	496	681
1993	36 564	699	1	558	772	2 692	4 535	862	3 238	18 925	3 538	140	603
1994	39 884	796	1	610	814	2 804	4 866	775	4 064	20 436	3 949	81	689

Note:
Figures include the shipments of fuels, metals and structural materials of all establishments in Canada, regardless of their industrial classification.
Source:
Statistics Canada, ***Canada's Mineral Production, Preliminary Estimates***, Cat. No. 26-202, Ottawa, various issues.

Table 11
Selected Statistics on Energy by Province and Territory, 1986-1993

	Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon and N.W.T.
Production (petajoules)													
	1986	9 736.4	141.0	-	82.7	44.7	535.5	410.3	117.7	693.3	6 486.5	1 152.0	72.7
	1987	10 250.4	136.1	-	83.6	41.2	566.4	400.3	99.8	732.0	6 852.5	1 262.6	75.9
	1988	11 175.4	143.0	-	101.9	43.6	537.8	421.4	85.2	820.7	7 577.3	1 359.5	85.0
	1989	11 349.7	118.1	-	103.6	41.6	518.0	424.1	94.0	845.9	7 637.6	1 482.0	84.7
	1990	11 392.6	125.0	-	101.6	46.7	482.4	402.2	100.1	901.1	7 669.7	1 478.7	85.2
	1991	11 789.0	127.5	-	121.8	43.8	512.9	436.6	108.8	887.3	7 869.0	1 588.6	92.6
	1992	12 217.5	125.6	-	131.1	39.0	527.7	421.6	120.6	969.2	8 388.3	1 394.1	100.3
	1993	12 995.2	141.2	-	107.2	40.7	557.5	461.6	121.4	1 021.1	8 893.2	1 553.3	98.0
Total domestic consumption[1,2] (petajoules)													
	1986	7 844.6	129.7	17.5	221.6	175.7	1 421.5	2 700.6	240.7	408.0	1 769.4	725.6	34.2
	1987	8 070.2	137.8	19.2	227.8	190.1	1 444.4	2 771.4	234.4	420.7	1 824.8	768.2	31.3
	1988	8 585.6	143.2	20.5	236.5	214.6	1 540.1	2 919.7	260.0	454.7	1 943.3	821.1	31.9
	1989	8 947.0	155.6	22.2	243.4	234.4	1 574.4	3 033.7	260.6	460.0	2 053.6	877.9	31.2
	1990	8 590.8	156.1	22.5	243.2	225.6	1 521.4	2 785.3	257.5	457.3	2 019.2	871.1	31.6
	1991	8 515.6	145.7	22.1	236.1	221.6	1 473.5	2 788.0	255.8	443.9	2 042.2	855.6	31.0
	1992	8 756.7	142.8	21.9	243.4	228.3	1 523.8	2 859.1	257.8	513.9	2 084.2	849.1	32.5
	1993	8 830.5	142.8	22.4	242.3	223.7	1 555.5	2 828.4	263.1	520.0	2 102.1	897.1	33.0
Consumption per capita (gigajoules)													
	1986	299.4	224.4	135.9	248.4	241.4	211.1	285.0	220.0	395.0	725.6	240.2	426.4
	1987	304.0	239.0	148.8	254.2	260.2	212.2	286.2	213.0	405.9	746.8	250.7	388.8
	1988	319.2	248.5	158.1	262.7	292.7	224.5	295.4	235.4	440.7	789.0	262.5	393.3
	1989	326.8	269.5	170.0	268.4	317.6	226.6	298.9	235.6	449.7	820.0	273.6	379.1
	1990	309.1	269.6	171.8	266.5	303.6	216.7	269.3	232.3	452.4	789.9	264.0	375.3
	1991	302.8	251.1	169.0	257.2	296.1	208.1	266.2	229.9	441.1	785.1	253.2	360.0
	1992	306.8	244.6	166.4	263.1	303.1	213.0	268.6	230.5	509.6	786.8	244.1	371.9
	1993	305.1	244.4	168.2	260.2	295.9	215.2	261.6	233.7	513.9	782.0	251.0	374.1

Notes:
1. Domestic consumption data are equivalent to gross availability data in Statistics Canada Cat. No. 57-003.
2. Includes consumption of energy commodities for non-energy purposes.
Source:
Statistics Canada, ***Quarterly Report on Energy Supply-Demand in Canada***, Cat. No. 57-003, Ottawa, various issues.

Table 12

Federal Government Environmental Protection Expenditures, 1986-1994

	1986	1987	1988	1989	1990	1991	1992	1993[1]	1994[1]
	thousand dollars								
Pollution abatement and control									
Sewage collection and disposal	-	-	-	-	-	-	150	275	-
Pollution control	61 983	67 297	87 142	113 085	118 855	20 221	4 329	1 004	5 870
Other environmental services	383 744	430 794	442 869	497 185	571 471	682 955	709 679	749 906	929 389
Total[2]	**445 727**	**498 091**	**530 011**	**610 270**	**690 326**	**703 176**	**714 158**	**751 185**	**935 259**
Natural resource conservation and development									
Agriculture	3 238 420	4 720 870	3 614 210	3 011 500	2 592 670	4 622 130	3 237 910	2 881 500	2 436 520
Fish and game	388 334	328 401	393 464	402 070	470 382	483 973	693 646	692 158	573 942
Forests	224 701	660 250	311 776	284 463	215 421	206 653	236 048	237 655	225 869
Mines, oil and gas	1 094 980	708 981	767 246	365 551	383 426	325 310	321 573	497 388	568 992
Other resource conservation and development	702 999	650 481	707 769	760 003	725 538	623 016	620 308	591 718	522 337
Total	**5 649 440**	**7 068 990**	**5 794 460**	**4 823 590**	**4 387 440**	**6 261 080**	**5 109 490**	**4 900 420**	**4 327 660**

Notes:
Figures may not add due to rounding.
Includes transfer payments to other levels of government.
1. Estimates.
2. There are no federal government expenditures on waste collection and disposal.
Source:
Statistics Canada, Public Institutions Division.

Table 13

Provincial, Territorial and Local Government Environmental Protection Expenditures[1], Selected Years

	Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
		thousand dollars												
PROVINCIAL AND TERRITORIAL GOVERNMENTS														
Pollution abatement and control														
Sewage collection and disposal[2]														
	1988	77 526	-	2 018	-	9 663	-	-	3 594	-	-	61 156	-	1 094
	1989	72 412	-	-	720	9 554	-	-	-	-	-	59 729	2 409	-
	1990	75 327	-	-	127	9 367	-	-	-	95	-	63 557	2 181	-
	1991	100 597	-	-	92	8 191	-	-	-	64	-	89 873	2 377	-
Waste collection and disposal														
	1988	54 022	330	2 098	2 878	3 899	-	27 488	2 039	-	262	15 028	-	-
	1989	114 495	163	2 150	8 817	4 579	-	36 648	5 481	-	31 029	25 425	202	-
	1990	125 943	296	2 268	12 546	5 850	-	50 234	5 415	-	38 515	10 673	158	-
	1991	160 863	261	3 170	12 672	5 907	-	73 066	6 493	8	40 108	18 975	202	-
Pollution control														
	1988	226 639	2 754	128	-	9 320	23 766	134 829	263	4 009	47 997	2 885	-	689
	1989	280 066	3 679	113	4 601	13 802	19 820	188 239	393	4 314	40 973	3 437	32	662
	1990	296 300	2 559	176	5 312	13 834	-	202 993	399	29 465	40 754	11	8	789
	1991	341 901	2 956	348	6 103	18 420	-	240 212	746	29 730	42 626	-	-	759
Other environmental services														
	1988	164 641	-	1 644	3 222	1 247	56 377	4 269	8 586	67 188	21 142	-	-	966
	1989	202 524	1 525	2 585	15 722	1 840	74 925	4 530	8 537	71 500	7 813	12 936	500	111
	1990	379 501	1 848	3 117	18 029	6 045	147 799	19 907	9 351	74 464	10 096	88 402	444	-
	1991	465 220	1 822	3 012	18 437	17 624	157 476	20 832	10 100	121 699	11 787	101 778	589	62
Total pollution abatement and control														
	1988	522 828	3 083	5 887	6 101	24 129	80 143	166 586	14 482	71 197	69 401	79 069	-	2 748
	1989	669 496	5 367	4 848	29 861	29 776	94 745	229 416	14 410	75 814	79 815	101 527	3 143	774
	1990	877 071	4 703	5 561	36 014	35 096	147 799	273 124	15 165	104 023	89 365	162 642	2 790	789
	1991	1 068 580	5 039	6 530	37 304	50 143	157 476	334 111	17 339	151 500	94 521	210 627	3 168	821

Table 13

Provincial, Territorial and Local Government Environmental Protection Expenditures[1], Selected Years (Continued)

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
						thousand dollars							
Natural resource conservation and development													
Agriculture													
1988	2 726 916	16 943	31 592	42 838	25 308	654 287	340 495	242 983	636 169	636 311	99 634	346	10
1989	2 834 386	18 629	34 309	40 853	30 577	638 860	329 100	278 030	611 185	755 443	97 062	326	11
1990	2 901 736	18 095	33 405	42 658	36 413	717 880	416 988	177 629	631 442	720 653	106 207	347	18
1991	4 168 575	15 108	42 418	39 741	39 284	835 784	466 226	473 086	1 119 182	1 033 826	103 331	485	104
Fish and game													
1988	302 864	43 445	3 313	10 713	14 830	87 862	63 249	6 797	5 593	25 668	28 889	6 008	6 496
1989	342 942	50 158	3 363	8 562	27 608	95 092	70 067	10 403	6 876	27 198	29 529	6 462	7 624
1990	349 733	46 291	3 742	6 903	23 905	111 413	77 668	9 686	9 621	28 907	16 338	7 314	7 943
1991	338 934	34 140	4 066	7 628	21 611	99 392	85 151	8 538	10 819	31 457	22 125	5 796	8 212
Forests													
1988	1 247 665	25 560	5 120	42 272	26 773	288 803	284 927	13 670	11 748	113 933	416 771	10	18 079
1989	1 394 897	29 767	5 739	80 212	21 765	292 842	266 760	15 699	69 916	111 643	468 092	788	31 674
1990	1 413 677	31 032	6 603	51 736	26 445	298 177	286 626	14 035	50 442	143 210	481 294	875	23 202
1991	1 537 011	26 602	6 722	50 064	30 629	310 061	293 912	12 483	81 156	126 184	571 995	848	26 356
Mines, oil and gas													
1988	977 089	12 456	-	14 436	3 483	79 996	36 437	10 753	17 268	704 543	54 875	1 690	41 153
1989	1 340 073	13 385	-	9 741	3 229	76 756	41 753	10 203	379 331	707 789	48 868	3 037	45 983
1990	990 898	19 744	-	10 640	3 886	81 812	41 592	9 782	126 073	603 688	44 376	1 271	48 031
1991	1 167 788	42 329	-	11 567	2 871	78 486	41 690	10 950	316 613	531 617	81 028	1 331	49 308
Other resource conservation and development													
1988	837 672	4 470	5 101	4 834	28 103	76 748	212 819	52 283	22 579	366 462	45 786	9 101	9 386
1989	860 072	3 711	6 979	5 454	35 271	80 178	224 993	74 531	26 831	269 099	110 895	5 568	16 562
1990	764 131	4 311	6 131	5 053	33 160	79 882	263 859	49 141	22 768	212 998	61 890	5 513	19 424
1991	806 594	3 804	5 562	9 369	29 465	65 955	313 445	32 752	22 042	213 629	83 369	6 534	20 668
Total natural resource conservation and development													
1988	6 092 206	102 874	45 126	115 093	98 496	1 187 696	937 927	326 485	693 357	1 846 917	645 955	17 156	75 124
1989	6 772 370	115 650	50 390	144 823	118 450	1 183 728	932 672	388 865	1 094 139	1 871 171	754 447	16 180	101 855
1990	6 420 174	119 472	49 881	116 991	123 809	1 289 165	1 086 734	260 274	840 347	1 709 458	710 105	15 321	98 618
1991	8 018 902	121 983	58 768	118 368	123 860	1 389 678	1 200 424	537 809	1 549 811	1 936 712	861 848	14 994	104 648
Parks[3]													
1988	192 326	7 207	3 040	4 652	8 905	29 730	51 609	17 516	3 749	35 820	30 086	11	-
1989	227 059	6 458	3 293	15 289	9 575	30 048	57 660	17 157	16 402	33 074	37 243	861	-
1990	225 968	6 442	3 663	7 186	10 053	31 707	66 482	18 278	17 072	33 020	31 500	565	-
1991	204 713	6 644	3 654	6 838	9 450	32 569	57 214	16 374	15 449	27 559	28 550	412	-
LOCAL GOVERNMENTS[4]													
Pollution abatement and control													
Sewage collection and disposal													
1986	1 138 020	15 870	1 861	19 523	27 222	298 598	448 513	55 779	34 313	116 101	114 158	1 234	4 851
1987	1 208 600	19 216	1 797	25 389	31 212	287 120	476 460	39 115	35 169	130 956	152 517	1 078	8 573
1988	1 413 610	19 426	1 796	38 941	30 740	377 887	597 643	40 072	36 301	118 368	142 171	1 483	8 781
1989	1 734 760	19 028	1 945	31 176	30 702	531 371	723 837	49 106	41 358	138 229	154 934	1 061	12 009
1990	2 002 000	24 951	2 165	38 281	40 240	659 991	778 073	52 055	42 458	161 963	185 334	2 074	14 412
1991	1 954 270	19 420	2 580	63 118	42 898	537 628	838 006	55 495	37 362	146 430	192 799	4 216	14 320
1992	2 126 730	21 655	2 703	43 063	44 067	502 636	924 897	95 831	42 765	199 254	230 974	5 980	12 900
1993	2 236 360	20 064	2 517	62 161	39 313	601 071	853 683	67 825	54 572	198 465	314 877	6 218	15 591
Waste collection and disposal													
1986	627 753	12 110	549	17 372	6 514	143 005	267 841	19 445	16 066	47 835	93 584	799	2 633
1987	714 493	11 264	480	46 967	8 229	154 344	297 685	21 613	20 583	50 148	99 156	488	3 536
1988	817 079	10 576	497	21 941	9 824	178 308	391 866	24 526	17 841	53 813	103 199	625	4 063
1989	935 818	11 915	581	24 059	12 156	195 986	462 601	26 080	16 766	58 925	122 472	580	3 697
1990	1 125 910	12 044	612	31 928	13 305	223 016	584 145	25 682	17 595	66 592	146 467	640	3 879
1991	1 228 220	14 183	667	41 172	14 825	267 306	607 933	26 043	17 993	72 961	160 562	684	3 893
1992	1 389 770	12 438	906	42 751	14 638	314 984	670 971	35 925	21 013	91 831	178 296	939	5 082
1993	1 406 330	12 784	938	47 958	15 789	346 162	655 612	31 268	20 222	89 196	179 247	950	6 204

Table 13

Provincial, Territorial and Local Government Environmental Protection Expenditures[1], Selected Years (Concluded)

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	thousand dollars												
Other environmental services[5]													
1986	76 909	5	-	200	-	33 978	39 960	471	58	163	2 058	-	16
1987	87 911	14	139	60	514	35 427	48 508	514	124	264	2 331	-	16
1988	75 200	14	151	107	404	32 988	37 769	676	193	273	2 614	-	11
1989	82 615	11	160	225	15	31 674	45 901	668	225	204	3 514	-	18
1990	82 331	6	176	286	1 854	32 024	43 182	733	274	-	3 695	-	101
1991	80 949	4	183	1 332	1 844	18 387	54 307	884	205	-	3 742	1	60
1992	92 083	310	192	1 304	1 547	20 411	61 518	515	302	449	4 995	515	25
1993	97 558	4	196	14	1 586	34 887	54 168	530	1 722	273	4 159	-	19
Total pollution abatement and control													
1986	1 842 690	27 985	2 410	37 095	33 736	475 581	756 314	75 695	50 437	164 099	209 800	2 033	7 500
1987	2 011 010	30 494	2 416	72 416	39 955	476 891	822 653	61 242	55 876	181 368	254 004	1 566	12 125
1988	2 305 890	30 016	2 444	60 989	40 968	589 183	1 027 280	65 274	54 335	172 454	247 984	2 108	12 855
1989	2 753 190	30 954	2 686	55 460	42 873	759 031	1 232 340	75 854	58 349	197 358	280 920	1 641	15 724
1990	3 210 230	37 001	2 953	70 495	55 399	915 031	1 405 400	78 470	60 327	228 555	335 496	2 714	18 392
1991	3 263 440	33 607	3 430	105 622	59 567	823 321	1 500 250	82 422	55 560	219 391	357 103	4 901	18 273
1992	3 608 580	34 403	3 801	87 118	60 252	838 031	1 657 390	132 271	64 080	291 534	414 265	7 434	18 007
1993	3 740 250	32 852	3 651	110 133	56 688	982 120	1 563 460	99 623	76 516	287 934	498 283	7 168	21 814
Natural resource conservation and development													
Agriculture													
1986	184 946	-	-	260	-	-	26 166	6 517	20 581	127 487	3 911	-	24
1987	170 102	284	-	259	-	-	27 041	6 792	20 420	111 012	4 261	-	33
1988	124 297	36	-	296	-	-	20 872	7 247	11 875	79 431	4 524	4	12
1989	163 413	-	-	346	3	1 912	22 126	7 864	20 632	105 507	4 995	17	11
1990	156 099	-	-	377	-	2 368	19 771	8 302	20 735	99 351	5 051	3	141
1991	168 376	-	-	373	-	2 645	26 245	7 801	25 811	99 764	5 610	6	121
1992	146 683	24	-	345	3	-	24 302	8 521	18 038	88 258	7 118	42	32
1993	139 388	25	-	346	52	40	14 492	8 776	18 215	90 055	7 309	44	34
Other resource conservation and development													
1986	153 199	139	181	537	2 090	34 051	73 469	8 162	3 750	17 392	13 104	-	324
1987	196 185	184	190	657	4 730	38 488	108 173	8 868	3 340	9 961	21 421	36	137
1988	225 945	533	148	953	5 273	41 905	119 391	9 888	4 349	8 223	35 204	23	55
1989	252 980	723	-	1 934	4 535	61 826	139 722	9 944	3 371	10 815	19 671	100	339
1990	316 331	789	-	837	4 898	76 782	173 697	11 103	4 050	10 327	33 488	194	166
1991	328 878	818	-	1 060	4 817	84 100	170 408	12 262	8 191	10 157	36 747	186	132
1992	307 959	788	-	1 357	4 162	52 497	182 251	11 063	4 453	11 336	39 709	222	121
1993	286 726	811	-	1 561	3 670	47 311	161 287	11 395	4 621	12 355	43 501	125	89
Total natural resource conservation and development													
1986	338 145	139	181	797	2 090	34 051	99 635	14 679	24 331	144 879	17 015	-	348
1987	366 287	468	190	916	4 730	38 488	135 214	15 660	23 760	120 973	25 682	36	170
1988	350 242	569	148	1 249	5 273	41 905	140 263	17 135	16 224	87 654	39 728	27	67
1989	416 393	723	-	2 280	4 538	63 738	161 848	17 808	24 003	116 322	24 666	117	350
1990	472 430	789	-	1 214	4 898	79 150	193 468	19 405	24 785	109 678	38 539	197	307
1991	497 254	818	-	1 433	4 817	86 745	196 653	20 063	34 002	109 921	42 357	192	253
1992	454 642	812	-	1 702	4 165	52 497	206 553	19 584	22 491	99 594	46 827	264	153
1993	426 114	836	-	1 907	3 722	47 351	175 779	20 171	22 836	102 410	50 810	169	123

Notes:

Figures may not add due to rounding.

1. Local government expenditures exclude transfers between municipalities. Provincial/territorial government expenditures include intergovernmental transfer payments.
2. Some provinces and territories report their sewage expenditures under water supply expenditures, which are not considered as environmental protection expenditures.
3. Data on expenditures for parks are only available for provincial/territorial governments.
4. Local government expenditures for 1992 and 1993 are estimated.
5. Local government expenditures on other environmental services may include expenditures specific to pollution control.

Source:

Statistics Canada, Public Institutions Division.

Table 14

Selected Statistics on Population by Province and Territory, Various Years

	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Total population (thousands)														
1981	a	24 900.0	576.5	124.0	856.4	708.4	6 568.0	8 837.8	1 038.5	978.2	2 303.8	2 836.5	24.1	47.9
1986	a	26 203.8	578.1	128.8	892.1	727.7	6 733.8	9 477.2	1 094.0	1 032.9	2 438.7	3 020.4	24.8	55.4
1991	a	28 120.1	580.3	130.8	917.9	748.5	7 080.6	10 471.5	1 112.5	1 006.3	2 601.3	3 379.8	29.1	61.3
1993	a	28 940.6	584.4	133.2	931.2	756.0	7 228.8	10 813.2	1 125.8	1 011.9	2 688.1	3 573.9	30.6	63.4
1994	a	29 248.1	582.4	134.5	936.7	759.3	7 281.1	10 927.8	1 131.1	1 016.2	2 716.2	3 668.4	30.1	64.3
2016[1]	b	39 372.0	606.3	159.4	1 061.9	846.8	8 849.9	15 803.6	1 248.0	979.1	3 955.0	5 704.3	51.6	106.1
Average annual growth (percent)														
1981 to 1994	c	1.3	0.1	0.7	0.7	0.6	0.8	1.8	0.7	0.3	1.4	2.3	1.9	2.6
Total fertility rate[2]														
1990	d	1.8	1.6	1.9	1.7	1.6	1.7	1.8	2.0	2.1	2.0	1.8	2.3	3.1
Life expectancy (years)														
1981 - Male	b	71.9	..	..	..	..	..	..	..	..	..	..	..	..
Female	b	79.0	..	..	..	..	..	..	..	..	..	..	..	..
1986 - Male	b	73.0	..	..	..	..	..	..	..	..	..	..	..	..
Female	b	79.7	..	..	..	..	..	..	..	..	..	..	..	..
1990 - Male	b	73.7	73.5	74.1	72.9	73.0	73.0	74.0	74.1	74.4	74.1	74.4	70.1	70.1
Female	b	80.8	80.2	81.8	80.3	80.9	80.6	80.7	80.7	81.6	81.2	81.4	76.5	76.5
Age-standardized mortality rate (deaths per 100 000 population, 1990)														
Male	e	641.4	709.8	704.0	689.1	652.7	694.7	627.9	622.7	590.0	611.8	593.8	721.9	837.0
Female	e	454.0	515.1	477.7	487.7	454.6	455.2	457.4	456.6	430.5	429.9	441.4	729.2	594.0
Infant mortality rate (deaths per thousand live births)														
1981	f	9.6	9.7	13.2	11.5	10.9	8.5	8.8	11.9	11.8	10.6	10.2	14.9	21.5
1986	f	7.9	8.0	6.7	8.4	8.3	7.1	7.2	9.2	9.0	9.0	8.5	24.8	18.6
1990	f	6.4	7.8	6.9	5.7	6.1	5.9	6.3	6.4	8.2	6.7	6.5	10.6	12.2
Urbanization (percent)														
1991	g	76.6	53.6	39.9	53.5	47.7	77.6	81.8	72.1	63.0	79.8	80.4	58.8	36.7
Households (thousands)														
1991	g	10 079.4	175.7	44.8	326.5	255.0	2 650.1	3 661.7	407.1	366.1	914.7	1 251.4	10.1	16.3
1993[3]	h	10 247.0	182.0	47.0	336.0	256.0	2 688.0	3 765.0	387.0	361.0	923.0	1 302.0	..	..
Expenditures on education (million dollars)														
1980	i	22 879.8	467.7	95.2	712.1	532.6	7 151.9	7 814.4	839.1	843.1	1 941.3	2 225.1	98.5	158.8
1985	i	34 579.9	741.1	150.4	1 131.6	877.8	9 441.4	12 070.2	1 424.5	1 390.5	3 602.1	3 241.9	178.1	330.3
1990	i	48 183.7	1 029.0	195.8	1 473.9	1 198.9	11 869.3	18 147.3	1 957.8	1 788.9	4 562.4	5 200.1	285.9	474.4
Land area (thousand square kilometres)														
	d	9 215.4	371.7	5.7	52.8	72.1	1 356.8	891.2	548.4	570.7	644.4	929.7	479.0	3 293.0
Population density (persons per km^2)														
1981	c	2.7	1.6	21.9	16.2	9.8	4.8	9.9	1.9	1.7	3.6	3.1	0.1	--
1986	c	2.8	1.6	22.8	16.9	10.1	5.0	10.6	2.0	1.8	3.8	3.2	0.1	--
1991	c	3.1	1.6	23.1	17.4	10.4	5.2	11.8	2.0	1.8	4.0	3.6	0.1	--
1993	c	3.1	1.6	23.5	17.6	10.5	5.3	12.1	2.1	1.8	4.2	3.8	0.1	--
1994	c	3.2	1.6	23.8	17.7	10.5	5.4	12.3	2.1	1.8	4.2	3.9	0.1	--
2016	c	4.3	1.6	28.2	20.1	11.7	6.5	17.7	2.3	1.7	6.1	6.1	0.1	--

Notes:
Figures may not add due to rounding.
1. Projection 3 - Medium growth.
2. The total fertility rate is based on the age-specific fertility rates for a particular year and refers to the number of children that each woman would, on average, bear in her lifetime. A generation would be replaced if, on average, each woman bore 2.1 children.
3. The total number of households for 1993 are estimated figures. Estimates are unavailable for the Yukon and North West Territories.

Sources:
a. Statistics Canada, intercensal estimates adjusted for net undercount and non-permanent residents.
b. Statistics Canada, Demography Division.
c. Statistics Canada, National Accounts and Environment Division.
d. Statistics Canada, ***Canada Year Book, 1994***, Cat. No. 11-402, Ottawa, 1994.
e. Statistics Canada, Health Division.
f. Statistics Canada, ***Mortality: Summary List of Causes***, Cat. No. 84-209, Ottawa, 1993.
g. Statistics Canada, Census of Population.
h. Statistics Canada, ***Household Facilities by Income and Other Characteristics***, Cat. No. 13-218, Ottawa, 1993.
i. Statistics Canada, ***Financial Statistics of Education***, Cat. No. 81-208, Ottawa, various issues.

Table 15

Selected Statistics on the Economy by Province and Territory, 1981-1994

	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Gross Domestic Product[1] (million 1986 dollars)														
1981	a	440 127	6 002	1 239	10 749	8 045	105 067	168 820	15 789	14 799	51 779	53 842	539	1 019
1986	a	505 666	6 970	1 567	13 239	10 447	116 536	204 494	18 588	17 453	56 844	56 204	587	1 414
1991	a	554 735	7 729	1 772	14 197	11 263	126 399	221 340	18 899	18 810	64 219	66 793	844	1 699
1993	a	570 541	7 634	1 822	14 677	11 824	129 689	225 807	19 110	18 401	68 235	70 332	735	1 624
1994	b	596 290	7 803	1 934	14 864	12 038	134 684	238 576	19 841	18 951	71 073	73 652	715	1 653
GDP per capita (thousand 1986 dollars per person)														
1981	c	17 676	10 411	9 992	12 551	11 357	15 997	19 102	15 204	15 129	22 475	18 982	22 365	21 273
1986	c	19 297	12 057	12 166	14 840	14 356	17 306	21 577	16 991	16 897	23 309	18 608	23 669	25 523
1991	c	19 727	13 319	13 547	15 467	15 047	17 851	21 137	16 988	18 692	24 687	19 762	29 003	27 716
1993	c	19 714	13 063	13 679	15 761	15 640	17 941	20 883	16 975	18 185	25 384	19 679	24 020	25 615
1994	c	20 387	13 398	14 379	15 868	15 854	18 498	21 832	17 541	18 649	26 166	20 077	23 754	25 708
Average annual real GDP growth 1984-91: Goods producing industries (percent)														
Primary	d	1.9	-4.0	-1.8	1.9	2.0	2.2	-1.0	2.2	4.6	2.0	2.7	28.4	-3.3
Manufacturing	d	1.1	-0.3	5.0	-0.1	2.2	1.5	0.5	1.1	3.1	3.3	1.7	21.0	7.7
Other goods producing industries	d	2.6	0.3	6.7	2.7	3.4	2.3	2.2	3.1	1.1	3.1	4.6	5.4	-4.0
GDP distribution by sector (1991): Goods producing industries (percent)														
Primary	d	20.7	24.2	34.6	20.7	17.9	9.6	7.7	26.9	61.5	53.9	24.3	55.9	64.3
Manufacturing	d	51.9	28.4	25.1	43.7	39.4	61.2	68.6	40.4	14.9	20.6	42.7	3.2	2.8
Other goods producing industries	d	27.4	47.4	40.3	35.6	42.7	29.2	23.6	32.7	23.6	25.5	33.1	40.9	32.9
Personal income per capita (1986 dollars per person)														
1986	a	16 853	11 731	12 535	14 088	13 044	15 774	18 612	15 224	15 017	17 744	16 902	19 167	19 865
1991	a	22 560	16 553	16 847	18 573	17 778	20 988	25 386	19 276	17 941	22 477	22 955	25 815	26 327
Passenger automobiles[2] (thousands)														
1981	f	10 199	142	49	350	252	2 379	3 831	461	392	1 216	1 116	7	6
1986	f	11 477	176	56	337	286	2 614	4 244	527	389	1 296	1 527	8	17
1991	f	13 061	202	64	426	312	2 978	4 847	544	416	1 424	1 807	20	20
1993	f	13 448	207	65	429	324	3 070	5 002	551	414	1 507	1 879	10	20
Passenger automobiles per capita (vehicles per thousand persons)														
1981	c	409.6	246.3	395.2	408.7	355.7	362.2	433.5	443.9	400.7	527.8	393.4	290.5	125.3
1986	c	438.0	304.4	434.8	377.8	393.0	388.2	447.8	481.7	376.6	531.4	505.6	322.6	306.9
1991	c	464.5	348.1	489.3	464.1	416.8	420.6	462.9	489.0	413.4	547.4	534.6	687.3	326.3
1993	c	464.7	354.6	484.8	461.0	429.0	424.7	462.6	489.5	409.3	560.7	525.7	317.8	310.5
Gasoline sales for automotive purposes (million litres)														
1981	g	30 782.5	587.1	171.3	1 141.1	1 070.8	8 104.6	12 610.2	1 323.7	1 460.3	..[3]	4 224.7	57.9	30.8
1986	g	25 859.2	521.9	165.1	1 039.8	914.1	6 578.4	11 715.2	1 293.0	..[3]	..[3]	3 551.8	54.6	21.7
1991	g	31 211.6	573.5	168.8	1 065.9	904.5	6 823.6	11 887.3	1 250.2	1 172.3	3 746.7	3 527.6	59.0	32.1
1993	g	32 734.9	585.1	174.0	1 085.3	961.1	7 037.7	12 255.2	1 253.9	1 544.9	3 873.7	3 869.5	61.3	33.1
Gasoline sales per capita (litres per person)														
1981	c	1 236.2	1 018.4	1 381.7	1 332.5	1 511.6	1 233.9	1 426.8	1 274.6	1 492.8	..	1 489.4	2 401 4	643.1
1986	c	986.9	902.8	1 281.9	1 165.6	1 256.2	976.9	1 236.1	1 181.9	..	..	1 175.9	2 201.2	391.3
1991	c	1 109.9	988.3	1 290.2	1 161.3	1 208.4	963.7	1 135.2	1 123.8	1 165.0	1 440.3	1 043.7	2 029.1	524.1
1993	c	1 131.1	1 001.2	1 306.4	1 165.5	1 271.3	973.6	1 133.4	1 113.8	1 526.8	1 441.1	1 082.7	2 002.5	522.5

Notes:
Figures may not add due to rounding.
1. The sum of the GDPs of the 12 provinces and territories is not equal to Canada's total GDP because the latter also includes wages and salaries of public servants working abroad.
2. Includes taxis and for-hire cars.
3. Net sales statistics are not available because the road tax was removed in both Alberta (April 1978) and Saskatchewan (April 1982).

Sources:
a. Statistics Canada, ***Provincial Economic Accounts: Annual Estimates, 1961-1993***, Cat. No. 13-213, Ottawa, 1995.
b. Statistics Canada, ***Provincial Economics Accounts, Preliminary Estimates, 1994***, Tables and Analytical Document, uncatalogued, Ottawa, 1995.
c. Statistics Canada, National Accounts and Environment Division.
d. Statistics Canada, Industry Measures and Analysis Division.
e. Statistics Canada, ***Canada Year Book, 1994***, Cat. No. 11-402, Ottawa, 1994.
f. Statistics Canada, ***Road Motor Vehicles, Registrations***, Cat. No. 53-219, Ottawa, 1992.
g. Statistics Canada, ***Road Motor Vehicles Fuel Sales***, Cat. No. 53-218, Ottawa, 1993.

ORDER FORM

National Accounts and Environment Division

AIL TO:
arketing Division
ublication Sales
tatistics Canada
ttawa, Ontario, K1A 0T6

FAX TO: (613) 951-1584
A Fax will be treated as an original order. Please do not send confirmation.

Please print)
ompany ______
epartment ______
ttention ______
ddress ______
ity ______ Province ______
ostal Code ______ Tel. ______ Fax ______

METHOD OF PAYMENT:

☐ Purchase Order Number (*please enclose*) ______
Authorized signature ______
☐ Payment enclosed $ ______
Please charge my: ☐ MasterCard ☐ VISA
Card Number
Expiry Date

Signature ______

atalogue umber	Title	Frequency/ Release Date	Annual Subscription or Book Price Canada $	United States US$	Other Countries US$	Qty	Total $
	PUBLICATIONS						
1-509E	Human Activity and the Environment, 1994	Occasional 06/94	35.00	42.00	49.00		
1-526	Households and the Environment, 1994	Occasional 04/95	27.00	32.00	37.00		
1-527E	Databases for Environmental Analysis: Government of Canada	Occasional 12/92	55.00	66.00	77.00		
1-529E	Databases for Environmental Analysis: Provincial and Territorial Governments	Occasional 08/94	75.00	90.00	105.00		
1-528E, No. 2	Environmental Perspectives: Studies and Statistics	Occasional 05/95	35.00	42.00	49.00		
	DISKETTE (Sold to purchasers of publication 11-509)						
1-5090XDE	Human Activity and the Environment, 1994	Occasional 06/94	15.00	18.00	21.00		
				SUBTOTAL			
:anadian customers add 7% Goods and Services Tax. (GST No. R121491807)				**GST (7%)**			
'lease note that discounts are applied to the price of the publication and not to the total amount which night include special shipping and handling charges and the GST.				**GRAND TOTAL**			

:heque or money order should be made payable to the *Receiver General for Canada - Publications*. Canadian clients pay in Canadian funds. :lients from the United States and other countries pay total amount in US funds drawn on a US bank.

)rder completed by: Date:

Subscriptions will begin with the next issue.

For faster service **1-800-267-6677** **VISA and MasterCard Accounts**

PF 03551 05/95

Statistics Canada Statistique Canada

Canada

BON DE COMMANDE

Division des comptes nationaux et de l'environnement

ENVOYEZ À:
Division du marketing
Vente des publications
Statistique Canada
Ottawa (Ontario) K1A 0T6

TÉLÉCOPIEZ AU: (613) 951-1584
Le bon télécopié tient lieu de commande originale. Veuillez ne pas envoyer de confirmation.

(*Veuillez écrire en caractères d'imprimerie s.v.p.*)

Compagnie ______________________

Service ______________________

À l'attention de ______________________

Adresse ______________________

Ville ______________________ Province ______________________

Code postal __________ Tél. __________ Télécopieur __________

MODALITÉS DE PAIEMENT:

☐ N° du bon de commande (*inclure s.v.p.*) ______________________

Signature autorisée ______________________

☐ Paiement inclus $ ______________________

Veuillez débiter mon compte: ☐ MasterCard ☐ VISA

N° de carte ______________________

Date d'expiration ______________________

Signature ______________________

Numéro au catalogue	Titre	Fréquence de parution/ Date de parution	Abonnement annuel ou prix de la publication			Qté	Total $
			Canada $	États-Unis $US	Autres pays $US		
	PUBLICATIONS						
11-509F	L'activité humaine et l'environnement, 1994	Hors série 06/94	35,00	42,00	49,00		
11-526	Les ménages et l'environnement, 1994	Hors série 04/95	27,00	32,00	37,00		
11-527F	Bases de données pour l'analyse environnementale: gouvernement du Canada	Hors série 12/92	55,00	66,00	77,00		
11-529F	Bases de données pour l'analyse environnementale: gouvernement provinciaux et territoriaux	Hors série 08/94	75,00	90,00	105,00		
11-528F, n° 2	Perspectives sur l'environnement: Études et statistiques	Hors série 05/95	35,00	42,00	49,00		
	DISQUETTE (Vendue aux acheteurs de la publication 11-509)						
11-5090XDF	L'activité humaine et l'environnement, 1994	Hors série 06/94	15,00	18,00	21,00		
				TOTAL			
Les clients canadiens ajoutent la taxe de 7 % sur les produits et services. (TPS N° R121491807))				**TPS (7%)**			
Veuillez noter que les réductions s'appliquent au prix des publications et non au total général; ce dernier pouvant inclure des frais de port et de manutention particuliers et la TPS.				**TOTAL GÉNÉRAL**			

Le chèque ou mandat-poste doit être établi à l'ordre du *Receveur général du Canada - Publications*. Les clients canadiens paient en dollars canadiens. Les clients à l'étranger paient le montant total en dollars US tirés sur une banque américaine.

Commande remplie par: Date:

Tout abonnement débute avec le prochain numéro à paraître.

Pour un service plus rapide, composez **1-800-267-6677** **Comptes VISA et MasterCard**

PF 03551 05/95

Statistique Canada Statistics Canada

Canad

ISBN 0-660-15573-7

9 780660 155739

11-5280XPE95001

Catalogue no. 11-528-XPE, No. 3

Environmental Perspectives

3

Studies and Statistics

Statistics Canada Statistique Canada

Canada

Data in many forms

Statistics Canada disseminates data in a variety of forms. In addition to publications, both standard and special tabulations are offered. Data are available on the Internet, compact disc, diskette, computer printouts, microfiche and microfilm, and magnetic tape. Maps and other geographic reference materials are available for some types of data. Direct online access to aggregated information is possible through CANSIM, Statistics Canada's machine-readable database and retrieval system.

How to obtain more information

Inquiries about this publication and related statistics or services should be directed to: System of National Accounts, National Accounts and Environment Division, Statistics Canada, Ottawa, K1A 0T6 (Telephone: (613) 951-3640) or to the Statistics Canada Regional Reference Centre in:

Halifax	(902) 426-5331	Regina	(306) 780-5405
Montreal	(514) 283-5725	Edmonton	(403) 495-3027
Ottawa	(613) 951-8116	Calgary	(403) 292-6717
Toronto	(416) 973-6586	Vancouver	(604) 666-3691
Winnipeg	(204) 983-4020		

You can also visit our World Wide Web site: http//www.statcan.ca

Toll-free access is provided **for all users who reside outside the local dialing area** of any of the Regional Reference Centres.

National enquiries line	**1 800 263-1136**
National telecommunications device for the hearing impaired	**1 800 363-7629**
Order-only line (Canada and United States)	**1 800 267-6677**

How to order publications

Statistics Canada publications may be purchased from local authorized agents and other community bookstores, the Statistics Canada Regional Reference Centre, or from:

Statistics Canada
Operations and Integration Division
Circulation Management
120 Parkdale Avenue
Ottawa, Ontario
K1A 0T6

Telephone: (613) 951-7277
Fax: (613) 951-1584
Toronto (credit card only): (416) 973-8018
Internet: order@statcan.ca

Standards of service to the public

To maintain quality service to the public, Statistics Canada follows established standards covering statistical products and services, delivery of statistical information, cost-recovered services and services to respondents. To obtain a copy of these service standards, please contact your nearest Statistics Canada Regional Reference Centre.

Statistics Canada
National Accounts and Environment Division
System of National Accounts

Environmental Perspectives

3

Studies and Statistics

Published by authority of the Minister responsible for Statistics Canada

June 1996

Price: Canada: $35.00
United States: US$42.00
Other Countries: US$49.00

Catalogue No. 11-528-XPE, No. 3
Frequency: Occasional

ISSN 1205-8386
ISBN 0-660-16515-5

Ottawa

Version française de cette publication disponible sur demande (n° 11-528-XPF, n° 3 au catalogue).

Note of Appreciation

Canada owes the success of its statistical system to a long-standing co-operation involving Statistics Canada, the citizens of Canada, its businesses and governments. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Over 50% recycled paper including 10% post consumer fibre

Environmental Perspectives 3

Studies and Statistics

Table of Contents

Symbols

The following standard symbols are used in Statistics Canada publications:

..	figures not available
...	figures not appropriate or not applicable
-	nil or zero
- -	amount too small to be expressed
e	estimate
p	preliminary figures
r	revised figures
x	confidential to meet secrecy requirements of the *Statistics Act*

Prefixes of the Metric System

Prefix	Abbreviation	Multiplication factor
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

Abbreviations

1986$	constant 1986 dollars
A	ampere
cm	centimetre
°C	degree Celsius
d	day
dB	decibel
EA	enumeration area
g	gram
GDP	Gross Domestic Product
ha	hectare
h	hour
Hz	hertz
J	joule
kg	kilogram
km	kilometre
km^2	square kilometre
km^3	cubic kilometre
km/h	kilometres per hour
kPa	kilopascal
kt	kilotonne
kWh	kilowatt hour
l	litre
m	metre
m^2	square metre
m^3	cubic metre
Mm^3	million cubic metres
mm	millimetre
min	minute
mol	mole
Mt	megatonne
µg	microgram
nec	not elsewhere classified
ng	nanogram
ppm	parts per million
ppb	parts per billion
ppt	parts per trillion
s	second
SIC	Standard Industrial Classification
t	tonne
TJ	terajoule
TAC	total allowable catch
W	watt

Preface

Environmental Perspectives: Studies and Statistics is devoted to disseminating the results of analytical projects and development of data detailing the relationship between the environment and the economy. This publication appears annually between issues of the quinquennial *Human Activity and the Environment,* which was last published in 1994.

Whereas *Human Activity and the Environment* is a comprehensive compendium of environmental-economic data, this publication presents a selection of data and analysis that reflect the current environmental statistics program at Statistics Canada.

This third volume of *Environmental Perspectives* presents new developments from the research program in the areas of environmental surveys and natural resource accounting. The environmental survey work focuses on environmental protection expenditures and the resource accounts examines Canada's land resource and its fishery. In addition, the annex of environmental statistics has been restructured and expanded and it now includes a section of summary statistics for the North American Free Trade Agreement (NAFTA) countries.

Environmental Surveys

- Chapter 1 provides an overview of the structure of the environmental satellite accounts, their relationship to the core elements of the Canadian System of National Accounts, and their correspondence with counterpart business financial accounts - with particular emphasis on the conventions for treatment of environmental protection expenditures.
- The challenges of measuring and interpreting environmental protection expenditures of the business and public sectors are explored in Chapter 2. An overview of current practices of other industrialised nations is provided for comparative reference.
- Chapter 3 presents an analysis of the environmental protection expenditures reported by the Canadian business sector over the period 1985 to 1993.
- Chapter 4 examines that part of the environment industry which provides consulting engineering and scientific and technical services to aid businesses develop and implement environmental management, protection and remediation activities.
- Environmental activities of the household sectors in Canada and Australia are examined in Chapter 5. Energy use, water use and waste management practices of households are compared.

Natural Resource Accounts

- Chapter 6 introduces the work on natural resource account development with a discussion of the importance of both physical stock and monetary measures to the examination of sustainability.
- Land Accounts: In Chapter 7, the recent history of land cover and land use data for Canada is examined from the perspective of policy shifts. A framework is proposed for the ordering of the existing mosaic of land information and for which new information can be developed. The application of the framework was piloted for New Brunswick, and the results are presented in Chapter 8. Chapter 9 explores the valuation of a subset of Canada's land, that devoted to agriculture.
- Chapter 10 presents a statistical profile of Canada's ocean fisheries.

Finally a set of broad economic, social and environmental statistics for NAFTA member countries are presented in Annex 1, while Annex 2 presents a similar range of statistics for Canada, the provinces and territories.

Acknowledgements

This publication was prepared by the Environmental Statistics sub-division of the National Accounts and Environment Division under the direction of Claude Simard, Director. The editor was Cynthia Baumgarten, Assistant Director.

The authors were:

Dale Austin
Cynthia Baumgarten
Michael Bordt
Alice Born
Giuseppe Filoso
Jeff Fritzsche
Pierre Gagnon
Craig Gaston
Ken Korporal
Anik Lacroix
Martin Lemire
Julie McAuley
Bruce Mitchell
Marcia Santiago
Doug Trant
Hélène Trépanier

Ray Bollman, Susie Boyd, Marie Drolet, Gerry Gravel, Bernard Gravelle, Susan Horsley, Rick Moll, Mitzi Ross, Marcia Santiago, Robert Smith, Hélène Trépanier, Claude Simard, Ghislain Valiquette, Neil Weatherdon and J. D. Wilson all provided valuable technical help and/or editorial advice. The French translations were edited by Anik Lacroix, Pierre Gagnon, Gylliane Gervais, Martin Lemire, Claude Simard and Hélène Trépanier. The marketing assistance of Mitzi Ross is also acknowledged.

Several divisions within Statistics Canada supplied statistics or provided other forms of assistance during the compilation process. These included the Agriculture Division, Industrial Organizations and Finance Division, Investment and Capital Stock Division, Public Institutions Division and Services, Science and Technology Division.

We are indebted for the contributions of Environment Canada, Fisheries and Oceans Canada and the Australian Bureau of Statistics.

1 A Comparison of Business Accounting and National Accounting from an Environmental Perspective

by Cynthia Baumgarten

Introduction

Until recently, the earth was assumed to be an infinite source of raw materials and an equally infinite receptacle for waste. The seemingly endless supply of free goods did not need to be counted. Resources were a natural endowment to be taken or used. There was no economic transaction associated with their taking or discard and no record of the remaining stock.

Increased awareness of the finitude of the earth's resource base, its ability to absorb waste and of the fragility of its ecosystems has changed this perception. This awareness is reflected everywhere. School children are being sensitized to the fragility of their natural surroundings, consumers are being warned about the impact of their wasteful attitudes, air pollution indexes and ozone depletion indexes are being published with associated health risk warnings, and environmental organizations are challenging the rights of current generations "to consume the earth" at a rate that will put at risk the ability of future generations to survive.

Government and non-government organizations have responded with both regulation and voluntary rules of self governance to preserve natural wealth and to protect the environment. "Sustainable development" is the rallying objective. Associated with this objective is a need for assessment of the remaining wealth, of the rate at which it is being depleted and of the impact on ecosystems. Statistical organizations around the world are determining how best to reflect the relationships between economic activity and the environment within their existing statistical and national accounting systems.

Like most accounting frameworks, the Canadian System of National Accounts (CSNA) reflects only market or monetary transactions. In a few instances, exceptions are made to extend the limits of the system to include non-market transactions, in order to ensure a consistent representation of a country's economic output. The Generally Accepted Accounting Principles of business accounting share a comparable philosophy. Business accounting is limited to economic events which for the most part are represented by market transactions. However, exceptions are made to ensure a meaningful representation of the "output", health and viability of the company. Steps are being taken to significantly expand the limits of both accounting systems to provide information that will reflect the "environmental perspective" in economic and financial assessment and analysis. The following paper outlines the components of the CSNA for which environmental satellite accounts are to be developed and draws links between them and the corresponding (and evolving) components of business accounts.

The CSNA

Statistics Canada has undertaken the development of a set of environmental statistics that will help both policy and economic analysts address environmental questions relating to sustainable development. The integrated economic accounts for Canada were taken as a model for the environmental accounts because of their utility as powerful analytical tools that support the examination of the interdependence of products and processes among all sectors of the economy. Since they are based on internationally accepted standards, they provide information which can be combined with that of other countries to assess the environmental issues which transcend international borders.

The CSNA provides a kind of statistical framework within which to formulate environmental policy and which links well to the framework for economic policy analysis. It is made up of 4 components:

- *the Input-Output Accounts* which measure productive activity and allow an overview of the relationship between the producers and purchasers in the economy;
- *the Income and Expenditure Accounts* which focus on income generated by productive activity and final expenditure on that production;
- *the Financial Flow Statements and the National Balance Sheet* which reveal the financing of economic activity in terms of flows of funds and levels of assets; and finally
- *the Balance of Payments and International Investment Position* which record transactions between Canadians and non-residents.

If a complete set of information describing the role of the environment in the economy were available, its incorporation in the CSNA would nevertheless be daunting. For example, this would require the addition of an environmental sector where the supply and absorption of environmental goods and services as well as resources supplied by mother nature would be accounted for in the various accounts of the

Table 1.1
An Abbreviated and Simplified Input-Output Table

	Intermediate expenditure				Final expenditure				
	Business sector				Household sector	Government sector	Business sector	Non-resident sector	
	Industry 1	Industry 2	...	Industry n					
Commodity 1	Intermediate inputs				Expenditure on goods and services	Expenditure on goods and services	Gross fixed capital formation and additions to inventory	Net exports of goods and services	= Gross business output
Commodity 2									
...									
Commodity n									
Primary inputs	Payments to labour, profits, investment income, depreciation				Payments to labour, depreciation	Payments to labour, investment income, depreciation			= Gross Domestic Product
	Total business inputs = Gross business output								

system. The nomenclature of commodities and assets used in the accounts would also have to be expanded to include resources and services provided by the environment to the business, personal, government and non-resident sectors. For example, the use of the environment as a dump for waste would be explicitly included as a service output of the environment sector, purchased by the other sectors.

Since it would take many years to develop a comprehensive and reliable set of data to implement such an extensive integration, Statistics Canada opted to start with a "satellite account" approach. The 1993 International System of National Accounts describes the role of satellite accounts in these terms (United Nations *et al.*, 1993; p. 489):

> Typically satellite accounts or systems allow for: (a) the provision of additional information on particular social concerns of a functional or cross-sector nature; (b) the use of complementary or alternative concepts, including the use of complementary and alternative classifications and accounting frameworks, when needed to introduce additional dimensions to the conceptual framework of national accounts; (c) extended coverage of costs and benefits of human activities; (d) further analysis of data by means of relevant indicators and aggregates; and (e) linkage of physical data sources and analysis to the monetary accounting system.

Although the measurement of physical stocks and flows of natural resources is relatively objective, complementary monetary assessments are quite challenging and controversial. The first objective in the development of the satellite accounts has been to measure in physical terms the stocks and flows of the natural assets which are directly affected by the economy, although some priority has been given to assessing their monetary value. The satellite accounts will allow integration of the environment into the two components of the CSNA that elaborate the stocks and flows; the Input-Output Tables and the National Balance Sheet.

The environmental satellite accounts: input-output component

The Input-Output Tables present information on the flows of goods and services in the economy between suppliers and users. Table 1.1 contains a schematic presentation of the Input-Output Tables prior to the introduction of environmental components. The rows titled "Commodity" identify the commodities used as intermediate input or for final consumption by the sectors identified along the columns: business, households, government and non-residents.

The set of columns under the general heading "Intermediate expenditures" presents the value of the commodities transformed into other products by the various industries of the business sector. This value includes the intermediate inputs, that is, the cost of the goods and services used in the production process, as well as the primary inputs, that is, the cost of labour and capital.

The set of columns under the general heading "Final expenditures" presents the value of the goods and services sold to households and governments for final consumption, to business for additions to fixed capital and inventory, and finally those traded with non-residents as exports and imports. The sum of all purchases (cells along a commodity row) adds up to a commodity gross output. The sum along the primary input rows adds up to Gross Domestic Product.

Some elements of the proposed environmental satellite accounts are already included in the Input-Output Tables. Items such as outlays for environmental protection are found in the intermediate inputs to production, in gross fixed capital formation and in additions to inventories. These will be identified separately to permit their inclusion in the satellite accounts.

Other elements of the proposed satellite accounts need to be developed. This is the case for the land use and the natural resource use accounts, recording the non-produced natural assets consumed by business, households and

Table 1.2

An Input-Output Table Adjusted to Include the Environment

<table>
<tr><td></td><td colspan="4">Intermediate expenditure</td><td colspan="4">Final expenditure</td><td></td></tr>
<tr><td rowspan="2"></td><td colspan="4">Business sector</td><td>Household sector</td><td>Government sector</td><td>Business sector</td><td>Non-resident sector</td><td></td></tr>
<tr><td>Industry 1</td><td>Industry 2</td><td>...</td><td>Industry n</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Commodity 1</td><td colspan="4" rowspan="4">Intermediate inputs</td><td rowspan="4">Expenditure on goods and services</td><td rowspan="4">Expenditure on goods and services</td><td rowspan="4">Gross fixed capital formation and additions to inventory</td><td rowspan="4">Net exports of goods and services</td><td rowspan="5">Gross business output</td></tr>
<tr><td>Commodity 2</td></tr>
<tr><td>...</td></tr>
<tr><td>Commodity n</td></tr>
<tr><td>Commodity</td><td colspan="4">Intermediate inputs; outlays for environmental protection (M)</td><td>Outlays for environmental protection (M)</td><td>Outlays for environmental protection (M)</td><td>Gross fixed capital formation and additions to inventory for environmental protection (M)</td><td>Net exports of goods and services for environmental protection</td></tr>
<tr><td>Non-produced natural assets</td><td colspan="4">Intermediate inputs (P)</td><td>Consumption (P)</td><td>Consumption (P)</td><td>Additions to inventory (P)</td><td></td><td></td></tr>
<tr><td>Waste</td><td colspan="4">Waste output (P)</td><td>Waste output (P)</td><td>Waste output (P)</td><td></td><td></td><td></td></tr>
<tr><td>Primary inputs</td><td colspan="4">Payments to labour, profits, investment income, depreciation</td><td>Payments to labour, depreciation</td><td>Payments to labour, investment income, depreciation</td><td></td><td></td><td>= Gross Domestic Product</td></tr>
<tr><td></td><td colspan="4">Total business inputs = Gross business output</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Note:
(P) indicates accounts for which only physical measures will be developed; (M) indicates accounts for which monetary measures will be developed.

governments, as well as the accounts showing the waste output from each of the sectors.

Table 1.2 illustrates how the satellite accounts - the shaded areas - relate to the standard Input-Output Tables. The lightly shaded cells in the rows entitled “Commodity” represent the elements already included in the CSNA since they are currently exchanged in the market for money. The cells in the rows with darker shading represent respectively the non-produced natural assets consumed and the waste returned to the environment, which are not currently traded in the market.

As satellite components, these resource use and waste outputs accounts will be expressed in physical units only (indicated by P in the table) and as such will not enter the core Input-Output Accounts. For all other satellite accounts, monetary measures (indicated by M in the table) and possibly some physical measures will be produced.

The environmental satellite accounts: asset component

At present, the CSNA provides measures of financial assets and produced assets including commercial land. These are found in the first two columns of Table 1.3. With the 1997 historical revision to the CSNA, the core accounts (i.e., the national balance sheet) will be expanded to include column 3: natural resources such as subsoil assets, timber and non commercial land. For these natural resources, opening stock, changes in volume, holding gains or losses and closing stock will be measured in monetary terms.

The stocks of natural resources incorporated in the balance sheet will also be expressed in physical terms. The shaded areas (both dark and light) in Table 1.3 identify the environmental satellite components of the CSNA asset accounts. The cells shaded in light grey represent the elements which will be common to both the core CSNA (the national balance sheet) and the environmental satellite accounts.

The CSNA and business accounting

Much of the information that Statistics Canada uses to build the Input-Output Tables and the stock - flow reconciliation accounts (which are currently implicit but will be published beginning with the 1997 historical revision) is derived from accounting statements. The information is collected from businesses with questionnaires whose wording and definitions, to the greatest degree possible, are consistent with Generally Accepted Accounting Principles. A close examination of the input-output table entries will reveal a similarity to the entries in business income statement. The Input-Output Accounts for the whole economy are basically derived from a summation of the income statements of individual businesses, although there are some basic differences.

Table 1.3
Asset Accounts and the Natural Resource Satellite Accounts in the CSNA

Stock - flow reconciliation accounts			
Assets expressed in monetary terms			Assets expressed in physical terms
Financial assets	Produced assets	Tangible non-produced assets (Natural resources)	Tangible non-produced assets (Natural resources)
Opening stock	Opening stock	Opening stock (M)	Opening stock (P)
Financial flows			
	Gross fixed capital formation		
	Gross fixed capital formation for environmental protection (M)		
Other changes in volume	Other changes in volume	Other changes in volume: natural resources (M)	Other changes in volume: natural resources (P)
Holding gains/losses	Holding gains/losses	Holding gains/losses (M)	
Closing stock	Closing stock	Closing stock (M)	Closing stock (P)

Note:
(P) indicates accounts for which only physical measures will be developed; (M) indicates accounts for which monetary measures will be developed.

Both macro-economic and financial analysts start with the same set of accounts, although the purpose, level and focus of their analyses differ. Macro-economic analysis focuses mainly on a measure of output or production for the overall economy. The economy is examined from the view of who (in very broad terms) uses the outputs or goods and services produced. It is also examined from the perspective of the inputs used to produce the output, namely primary inputs (the factors of production, labour and capital, plus other charges against production such as net indirect taxes) and intermediate inputs (the goods and services used). The analyst uses the input-output matrix format in which total business inputs equal total business outputs. The objective is to examine the relationship among the components of the economy as a whole.

Financial analysts also examine inputs and outputs, although they rarely rely on an input-output matrix format for their analysis. They use income statements of individual businesses and compare them to those of similar businesses. The objective is usually to identify the best candidate for investment. Revenue generation is a major facet. The analyst wants to know the relationship between the expenses and the revenues. What mix of inputs or expenses maximizes output for sale? Do revenues or sales cover expenses and still provide an expected return to the owners? To enhance the analysis, business accounting attempts to match expenses with associated revenues when building the income statement.

There are differences in treatment between the two approaches, with respect to inventory change and investment in the form of own account construction.

Inventories: For the economist, additions to inventory contribute to the supply of goods regardless of by whom they are produced, held or owned. They are included in the measure of output or production. For the financial analyst examining an individual business, it matters who owns the inventory. Until the inventory is sold and revenue generated, production costs associated with additions thereto are explicitly excluded from the expenses shown in the income statement. This approach ensures that the expenses charged against income or revenue for the period represent costs associated with that revenue. Although the accounting equivalence between total input (expenses plus return to owner's capital) and total output (revenues) is preserved, neither total includes a value for production added to inventory during the period.

Investment in fixed capital: When a business purchases equipment from another company, the value of the purchase does not appear as an expense in the income statement. Rather, it is capitalized, that is, added to the fixed asset account, and a counterbalancing adjustment is made to the cash account. In other words, it is directly recorded on the balance sheet and does not flow through the income statement. However, the proceeds from the sale of the fixed capital will appear in the income statement of the seller. On the other hand, when a business produces its own fixed capital, using its own workforce and supplies to build a storage facility for example, the expenses associated with this production are not included in the income statement. Since the resulting product is not to be sold but rather used on own account, there are no direct sales against which to match the expense. Therefore, it is treated as if it were purchased fixed capital; entries are made to the balance sheet, fixed capital and cash accounts to reflect the value of the additional facility. Unlike purchased capital, however, there is no seller on whose income statement the production is recorded. As a result, own account construction must be added explicitly to the measure of production for the economy.

The treatment of these two elements, additions to inventories and investment in fixed capital, is one of the main conceptual differences between economic or national accounting and financial accounting. The remaining accounts of the two systems correspond quite favourably. Table 1.4 compares the business input column of the Input

Table 1.4
Correspondence Between the CSNA Input-Output Account and the Business Income Statement

Input-output account in the CSNA (current expenses)					Business income statement (current expenses)
	Industry 1	Industry 2	...	Industry n	
Commodity 1	Intermediate inputs				Purchased materials and services (adjusted for change in inventories and own account additions to fixed capital) e.g., heat, light, telephone, rent, repairs and maintenance, transportation, advertising, legal and other consultative services, materials and supplies to be transformed, etc.
Commodity 2					
... Commodity n	Intermediate inputs: outlays for environmental protection (M)				Purchased materials and services (adjusted for change in inventories and own account additions to fixed capital) e.g., waste disposal charges; charges for pollution prevention and abatement; costs of remediation of damage; research and development; environmental assessments; environmental administration; resource conservation activities; environmental losses: fines, penalties, damage payments, shut down of installations
Non-produced natural assets	Intermediate inputs (P)				No corresponding financial accounts
Waste	Waste output (P)				No corresponding financial accounts
Other inputs	Payments to labour, indirect taxes, profits, investment income, depreciation				Payments to labour, indirect taxes, profits, investment income, depreciation
	Total business inputs				Total business costs and profits before interest payments and before direct taxes

Note:
(P) indicates accounts for which only physical measures will be developed; (M) indicates accounts for which monetary measures will be developed.

Output Table with the elements of the business income statement.

Table 1.5 presents a comparison of the stock - flow reconciliation in the CSNA and in business accounting. The correspondence between the two is a reflection of the sound business accounting framework upon which the CSNA was patterned.

Environmental satellite account data requirements: input-output component

Development of the environmental satellite input-output accounts will require information on the use of natural resources and production of all environmental goods and services. This implies that additions to inventories and revenues from sales will all need to be separated into categories of environmental and non environmental goods and services. Likewise, the natural resources and the goods and services used in the production of environmentally friendly goods and services, including environmental protection expenditures, will need to be identified.

The quality of the environmental protection expenditure satellite account, the light grey cells in Table 1.4, will depend largely on the ability of business to report environmental protection expenses in their books. The identification of exclusively environmental costs should be straightforward. The costs incurred for both environmental and other reasons will require some form of allocation. A Canadian Institute of Chartered Accountants (CICA) research study report suggests that "while the task of allocating costs between environmental and non-environmental categories may be very difficult, similar cost allocations are made in many other situations under the historical cost model (for example, research and development costs)" (CICA, 1993; p.11).

As noted earlier, the business accounting decision to capitalize an expenditure rather than treat it as a current expense is largely governed by the underlying principle of matching costs with associated economic benefits. The application of this matching principle to environmental protection expenditures gives rise to a whole range of options for prior period adjustments, current expenses and capitalization. For example, costs incurred in the current period to clean up environmental damage etc. caused in a prior period could be treated as prior period adjustments or current expenses. Current environmental expenses that are related to expected future economic benefits could be candidates for capitalization if they are "recoverable" by the firm.

Table 1.5
Stock and Flow Reconciliation: the CSNA Versus Business Accounting

CSNA: Capital account (excluding inventories)	Business: Capital account
Opening stock	Opening balance
Gross fixed capital formation	Additions to capital
Gross fixed capital formation for environmental protection (M)	Additions to capital and capitalized expenditures for environmental protection
Other changes in volume	Other changes in volume
Holding gains/losses	Valuation adjustments
Closing stock	Closing balance

Note:
(M) indicates accounts for which monetary measures will be developed.

In environmental accounting for businesses, the classification and treatment of an expenditure is governed by its nature or circumstances as well as by its ultimate beneficiary. Since environmental accounting is fairly new, guidelines are evolving as new situations arise. A CICA Study Group has reviewed the topic and has put forward a number of proposals for revisions to the CICA accounting guidelines.

Presently, the measure of gross fixed capital formation in the CSNA is closely linked to the measure of capital in business accounts. It includes new tangible assets, namely, plant and equipment, replacement and major alterations of capital installations, and various expenses which are capitalized along with the cost of the fixed assets. In only a few instances, do the guidelines of the two accounting systems differ significantly. The treatment of expenditures for environmental protection in the environmental satellite accounts should also closely follow the guidelines and standards established in business accounting for the capitalization of environmental expenditures. As these evolve, so too will those for investment on environmental protection in the environmental satellite accounts.

Statistics Canada is attempting to move forward with measures of environmental expenditures by developing a follow-up survey to its 1989 pilot survey of pollution control and abatement. Among the many challenges of developing the survey is the determination of an appropriate classification of categories for environmental expenditures - both current and capital.

As seen in Table 1.4, there are no corresponding business accounts which record the value or volume of natural resources used as input to production nor the value or volume of waste output.

Volumes of natural resource inputs used in production are currently collected from business' internal management records. This practice will continue.

Waste output will require special attention in the satellite accounts. Although the payments to the waste management industry to remove the waste are recorded as expenses, there are no entries for direct emissions into the environment. Waste by definition has no value and therefore its production and discard are not recorded. However, to analyse the impact of economic activity on the environment, measures of waste output are critical. Again, internal management records may provide some of this information. In addition, the environmental satellite accounts will rely on sources outside of business accounting to develop physical measures of waste output. Greenhouse gas emissions have already been derived for all sectors and similar plans are under way for other waste outputs.

Environmental satellite account data requirements: asset component

The development of satellite accounts for natural resource assets in monetary and physical terms will benefit only marginally from business accounting records. Information on the stocks of natural resources held by business will of course be used. However, the bulk of Canadian resources which belong to no one (or everyone) remain to be counted and valued. This exercise is the subject of other papers in this and other issues of *Environmental Perspectives*.

Conclusion

One of the critical elements to the successful development of the environmental satellite accounts will be the acceptance of the business sector to account for its transactions relating to the environment in a standard and consistent manner and its willingness to share that information with Statistics Canada. Another element will be the fit between business accounting with respect to the environment and the environmental satellite accounts. To date, the indications have been quite positive.

References

Canadian Institute of Chartered Accountants, 1993, *Environmental Costs and Liabilities; Accounting and Financial Reporting Issues*, Toronto.

United Nations, Commission of the European Communities, International Monetary Fund, Organisation for International Cooperation and Development and World Bank, 1993, *System of National Accounts 1993*, ST/ESA/STAT/SER.F/2/Rev.4, New York.

2 Environmental Protection Expenditures: Conceptual Issues and Current Practices

by Craig Gaston and Anik Lacroix

For the past five years Statistics Canada has been involved in developing a system of environmental and natural resource accounts[1] that will be satellite components of the Canadian System of National Accounts. One of these accounts, the environmental protection expenditures account, remains one of the least complete sets of environmental information. Although much development work has been done internationally (Eurostat, 1994), difficult conceptual and practical problems remain for the development of consistent data for this account. Statistics Canada is currently developing data on environmental protection expenditures made in household, business and public sectors.

Text Box 2.1
Definition of Environmental Protection Expenditures

Environmental protection expenditures are defined in the *1994 Environmental Protection Expenditures Survey* as all operating and capital expenditures incurred in order to comply with environmental regulations or conventions which apply to Canada. Examples of environmental regulations include the Canada Fisheries Act Regulations on liquid effluents from the pulp and paper, metal mining and petroleum refining industries (e.g. regulations pertaining to the Environmental Effects Monitoring Programme such as assessments of aquatic effects of mining in Canada). Environmental conventions include any formal multi-party commitment to meet specific targets relating to habitat protection and waste and pollution abatement, such as the Canada-U.S. Air Quality Agreement.

Environmental protection expenditures consist of expenditures undertaken with the intention of preventing, reducing and remedying environmental degradation or preserving the environment. They include expenditures for pollution abatement and control and expenditures for restoring wildlife and habitat, along with associated expenditures for environmental monitoring, environmental assessments and audits, and expenditures for reclamation and decommissioning of sites. Expenditures to improve employee health, workplace safety and site beautification are excluded.

Conceptual issues

Two reasons are frequently cited for measuring environmental protection expenditures:

- to gauge the commitment of countries (of governments, businesses and households) to prevent environmental degradation;
- to measure the cost to economic agents of environmental regulation.

Environmental protection expenditures are of two types (Text Box 2.1): those that treat pollution (or any other degradation) once it has been generated and those that change the production (or consumption) process to reduce or prevent pollution from being generated, or to reduce the amount of resources used. The first type, end-of-pipe expenditures, are intended only to abate and control pollution. Since there is no immediate financial advantage for the polluter in introducing this type of solution, the purpose is unambiguous. The second type of expenditure, for integrated solutions, can save raw material, energy in some cases and labour costs. There can be, in this case, a financial advantage. Commitment to protection of the environment is therefore clear in the first case but ambiguous for the second.

This fact has been noted by environmentalists and businesses alike (Knight, 1995; p.8) and there is increasing agreement that environmental protection expenditures are not a good measure of commitment to environmental protection. For this purpose it is more meaningful to measure the actual reduction in the quantity of pollution generated rather than the amount of money spent. These physical measurements have their own conceptual difficulties, particularly when it is a question of producing an aggregate measure, yet it is possible to focus on individual pollutants or classes of pollutants to determine progress.

Environmental protection expenditures are, however, a useful measure of the economic cost to society of protecting the environment. There is no international consensus in resolving the problem of separating environmental from other investment purposes. The most common technique used by member countries of the European Union (Eurostat, 1994) is to determine, for each type of process considered, a standard or reference technology that does not meet the latest regulatory requirements. The difference in cost between

1. This system of satellite accounts will consist of a Natural Resource Stock Account, a Natural Resource Use Account, a Waste Account and an Environmental Protection Expenditures Account.

an investment that conforms to the latest standards and the reference technology investment is deemed to be the environmental protection expenditure. It should be emphasized that the cost of the reference technology is often hypothetical since it may no longer be marketed in a given country as technological evolution moves towards cleaner processes.

Underlying this approach is the assumption that the reference technology is less expensive than that which has been adapted for environmental purposes. Although this may hold for some investments, it is not always the case. For instance, experts agree that a new pulp mill that generates zero effluent "would cost essentially the same as a conventional mill to build and operate" (McCubbin, 1994; p. 15). In other words, if environmental protection is incorporated into the initial design important gains can be made. Also, in other areas new technologies are being developed that reduce waste and pollution by using resources more efficiently. Even if these investments are more substantial than investments in a reference technology, they may become cost effective in the long run. Consequently, under this profitability criteria there would be no environmental cost. In other words, if the savings from decreased operating costs outweigh the additional capital costs required, the environmental protection cost is zero. The Netherlands is one of the few countries that takes profitability into account in determining environmental cost (de Boo, 1993).

From the above discussion it would seem reasonable to make a distinction between expenditures for end-of-pipe and expenditures for integrated processes. The former can provide a clear indication of costs that have little or no economic benefit (except to the firms that specialized in the production of environmental protection goods and services). It is not always feasible for organizations to adopt the best solution, which is often one that changes the technological process. It can be much more expensive and difficult to implement even if its long-term payoff proves to be higher. End-of-pipe solutions provide, therefore, an indication of the cost of not adopting more efficient solutions which reduce the use of energy and materials. This is not to imply that it would be possible to avoid entirely end-of-pipe solutions. There will always be a need for sewage treatment facilities and some abatement requirements are too urgent to wait for the appropriate process change technology to be implemented.

Another area which poses conceptual difficulties is the allocation of environmental protection expenditures by environmental medium: air, surface water and land (including groundwater). The difficulty here is that pollutants do not necessarily remain in the medium to which they are released. Air emissions are eventually deposited on land or water and contaminated groundwater ultimately seeps into streams and rivers. There is no satisfactory solution to this problem but the distinction still has some use if for no other reason than it provides market information for broad categories of pollution abatement equipment.

Current practices

Business sector expenditures

Surveys on environmental protection expenditures are currently conducted by industrial associations in Austria, Germany and the United Kingdom and by the statistical offices of most member states of the European Union. Austria, Germany, the Netherlands, the United States and Japan have been conducting regular surveys since the 1970s and Australia began a regular survey in 1990.

Some countries, notably the United States and Australia, have chosen to leave the decision about which costs to include to the survey respondent. However, the United States has recently established some rules of thumb to help respondents determine what proportion of the cost of their process-change investments is for environmental protection. Provision of methodologies to help the respondent identify the environmental protection expenditure component of an investment would require considerable technical knowledge on the part of the surveyor. Furthermore, there would be many unique situations to address. Few statistical offices have been able to afford the cost of the necessary specialists and research.

Statistics Canada conducted a pollution abatement and control (PAC) survey for 1989 (Gaston, 1993). This survey requested information on end-of-pipe expenditures and although it covered all sectors of the economy, it was restricted to those firms that had previously reported PAC expenditures.[1]

Statistics Canada has just conducted an environmental protection expenditures survey for 1994. It was intended to measure the cost to companies of environmental regulations and conventions[2] and it covered a broader range of environmental activities than the 1989 survey, such as process changes for PAC, wildlife and habitat protection, cleanup, monitoring and environmental assessments and audits. No attempt was made however to define the environmental criteria with respect to process-change investments on the 1994 questionnaire because of the difficulties in estimating what share of total spending the environmental motive should have. Instead the survey left to the respondent the decision on what proportion of a multipurpose investment to include. This means that, for the time being, Canada's approach is more in line with that of the United States and Australia than with European Union countries.

A pilot survey was conducted during the summer of 1995 and the full survey was mailed in October. The survey cov-

1. Those establishments that received the long questionnaire in the *Capital and Repair Expenditure Survey* and reported having PAC expenditures in the previous 3 years.
2. A convention is defined as any multi-party agreement, with explicit targets, to reduce pollution. The main criteria is that the agreement reflect more than the intentions of an individual company.

ered establishments with fifty or more employees in forestry, mining, crude oil and natural gas, electric power and the manufacturing sectors deemed most likely to have substantial environmental protection expenditures. From the results of the pilot survey it was determined that smaller companies (with less than 50 employees) in the selected industries either had no environmental protection expenditures or they could not make reasonable estimates of these types of expenditures.

In addition to these surveys, regular information on capital expenditures for pollution abatement and control has been collected since 1985. Statistics Canada's *Capital and Repair Expenditure Survey* asks respondents to provide data on capital expenditures by type of asset, several of which pertain specifically to pollution abatement and waste and sewage disposal. The survey, which is restricted to capital expenditures, does not distinguish between end-of-pipe and integrated process investments. However, the survey provides the only historical PAC information available. Statistics Canada has prepared a time series on PAC expenditures from this survey.[1]

Apart from the above sources there is very little information available historically on environmental protection expenditures for Canada. Environment Canada commissioned a survey for the year 1989 to Dunn and Bradstreet. The definition of environmental protection expenditures was broader than that of Statistics Canada's 1989 PAC survey (Dun and Bradstreet, 1991) so the results are not comparable. This survey was notable for the information it provided on the use and prospective use of environmental protection technologies according to environmental media (air, water, solid waste land management).

Some administrative data do exist from Revenue Canada's Accelerated Capital Cost Allowance Program for air and water pollution abatement equipment (Classes 24 and 27). Firms that were in business prior to 1974 were allowed to write off the costs of pollution abatement equipment over three years rather than the longer write-off period that generally applied. This information is inadequate for statistical purposes for several reasons. The program did not apply to newer companies, thus there is no data on expenditures of newer companies. In years of low or no profitability, companies tend not to take advantage of these allowances thereby obscuring the timing of such expenditures. In some years of the program's existence, other tax provisions offered similar or more favourable write-off periods thereby reducing the apparent amount of expenditures for the pollution abatement equipment.

Other partial information exists for some industries; for example, *Pulp and Paper Canada* publishes an annual report of capital expenditures on pollution abatement and control by pulp and paper companies.

1. See Chapter 3 in this publication.

Public sector expenditures

The measurement of environmental protection expenditures by governments is complicated by a similar problem to that of the private sector. Many expenditures to protect the environment can also be viewed as industrial development expenditures, such as expenditures relating to forest or fish management, agricultural development or energy programs. An example is Fisheries and Oceans Canada's Atlantic Fisheries Adjustment Program (AFAP). One of its main elements is rehabilitation of northern cod species through adoption of new conservation measures, increased monitoring, scientific research for depleted fish stocks, and implementation of individual quotas and adjustment programs for workers affected by conservation measures. Should these adjustment programs be considered entirely as environmental protection programs? The AFAP also promotes economic diversification activities which stimulate the creation of new markets and the development of underutilised species with a focus on aquaculture. Even though economic diversification may help protect certain fish species, it is difficult to determine the pure environmental motivation of the program.

This problem is best exemplified in the Financial Management System (FMS) used to classify government expenditures where there is one broad category called "natural resource conservation and industrial development". Almost 75% of consolidated government capital and current expenditures for environmental protection in 1991 was in this category. How much of this expenditure ought to be considered as expenditure for environmental protection is very difficult to assess. To sort out the components would require a programme by programme assessment of the expenditure purpose. In the absence of such an evaluation mechanism, an alternative would be to develop an expenditure classification that is based on purpose. The implementation of the Federal Sustainable Development Initiative should provide an impetus to keep more accurate records on federal government expenditures for environmental protection.

Other challenges in preparing a time series of government expenditures on environmental protection include: different levels of detail over time and by level of government; difficulty in eliminating double counting because of lack of information on transfers between governments; and reporting delays from reliance on administrative data in lieu of direct surveys.

Despite these obstacles, Statistics Canada intends to produce an account of government expenditures on environmental protection. It will consist of a time series of current and capital expenditures by each level of government. Data sources include the public accounts, other administrative sources and surveys. Available data have been published recently on PAC expenditures as well as on conservation and natural resource development expenditures since 1970 (1965 in some cases) (Lacroix, 1995).

Conclusion

The difficulties associated with the isolation and measurement of integrated environmental protection expenditures remain to be resolved. If the expected evolution of environmental protection from end-of-pipe to process-integrated solutions occurs, it will be difficult to monitor. The Netherlands has reported some evidence to this effect but few countries have been able to demonstrate a statistical methodology sufficiently rigorous to confirm this. Nevertheless, the measurement of end-of-pipe expenditures remains important since these represent costs which are not offset by increased resource and energy efficiency. The environmental protection expenditures that we can measure with confidence represent not so much the progress in reducing pollution but rather, the failure to implement a more efficient and clean alternative to an end-of-pipe solution.

References

de Boo, Abram J., 1993, "Costs of Integrated Environmental Control," *Statistical Journal of the United Nations ECE*, volume 10, New York, p. 47-64.

Dun & Bradstreet Canada, 1991, *Market Survey of Environmental Expenditures by Canadian Business*, Report prepared for Environment Canada, Duns Marketing Services, Ottawa.

Eurostat, 1994, *Environmental Protection Expenditure: Data Collection Methods in the Public Sector and Industry*, Luxembourg.

Gaston, Craig, 1993, "Pollution Abatement and Control Expenditures," in *Environmental Perspectives 1993: Studies and Statistics,* Statistics Canada, Catalogue No. 11-528E, Ottawa, p. 59-62.

Knight, Peter, 1995, "More May be Less," *Financial Times* [London], February 1.

Lacroix, Anik, 1995, "Government Expenditures on Environmental Protection," in *Environmental Perspectives 2: Studies and Statistics,* Statistics Canada, Catalogue No. 11-528E, No. 2, Ottawa, p. 89-100.

McCubbin, Neil, 1994, "A Bleaching Revolution is in Progress," *Pulp and Paper Canada*, April.

3 Private Sector Investments in Pollution Abatement and Control

by Pierre Gagnon

Introduction

This chapter presents the results of an analysis of data obtained from Statistics Canada's survey of capital expenditures. The analysis involves business-sector capital expenditures for pollution abatement and control (PAC) from 1985 to 1993; current expenditures are excluded. Public-sector (federal, provincial and municipal governments) expenditures were analysed in a previous study (Lacroix, 1995).

Environmental regulations adopted by the various levels of government have played an important role in the evolution of private-sector PAC expenditures. However, it is difficult to attribute increases in PAC investments specifically to those regulations adopted in recent years. Many investments were made in anticipation of regulations soon to be imposed, such as the Municipal-Industrial Strategy for Abatement, which addressed water pollution in Ontario. Other significant expenditures were the result of a federal-provincial agreement on reducing sulphur dioxide emissions.[1] The agreement mainly targeted smelters and electrical power plants. There have also been a series of federal and provincial regulations targeting the paper and allied products industry and contributing to the increase in PAC investments in that industry since the late 1980s. Some of the federal regulations adopted in 1991 included the possibility, for some businesses, of an extension until 1995 to comply with environmental standards (Table 3.1). In addition to the regulatory framework, public pressure became an increasingly important factor during the 1980s and may also have contributed to the increase in PAC expenditures.

Analysis by industry

From 1985 to 1993, capital expenditures for pollution abatement and control (in the business sector) increased from $141 million to $1.1 billion. In 1990, those expenditures peaked at $1.3 billion (Table 3.2).

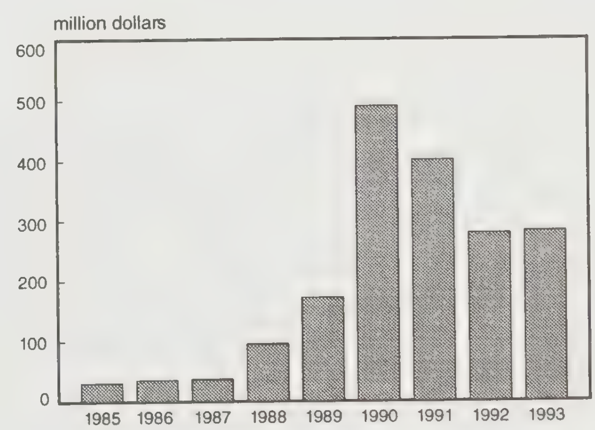
The manufacturing sector

Manufacturing is one of the most important sectors with respect to private-sector PAC investments. The percentage of manufacturing sector investments remained steady at about 80% to 90% of total investments between 1985 and 1987 (Table 3.3). After that year, the percentage fell from 80% to less than 60%, whereas environmental expenditures in the electricity, gas and other utilities industry grew. Ontario Hydro's large investment alone was a major contributor to the substantial decrease in the manufacturing sector's percentage of PAC investments. Manufacturing sector industries that account for the largest investments are mainly the paper and allied products industry (note that pulp and paper is the largest single contributor in this industry), primary metals and chemical and chemical products industries.

The paper and allied products industry

This industry expanded considerably in the late 1980s, resulting in a substantial increase in total investments. Between 1985 and 1989, investments increased from approximately $2 billion to $5.5 billion. In the early 1990s, the recession had a strong impact on pulp and paper production and total investments dropped from $5.5 billion to $2.2 billion. PAC investments increased from $31 million to $490 million from 1985 to 1990, and then fell to $282 million in 1993 (Figure 3.1 and Table 3.3). Despite this decrease,

Figure 3.1
PAC Investment in the Paper and Allied Products Industry, 1985-1993



Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

1. Sulphur dioxide, along with nitrogen oxides, combine with water in the atmosphere to form the main components of acid deposition.

Table 3.1
List of Federal Regulations

	Adopted
Canadian Environmental Protection Act	
Asbestos Mines and Mills Release Regulations	June 14, 1990
Chlor-Alkali Mercury Release Regulations	February 15, 1990
Chlorobiphenyl Regulations	February 21, 1991
Chlorofluorocarbon Regulations, 1989	February 15, 1990
Contaminated Fuel Regulations	August 14, 1991
Export and Import of Hazardous Wastes Regulations	November 12, 1992
Federal Mobile PCB Treatment and Destruction Regulations	December 14, 1989
Fuels Information Regulations No. 1	..
Gasoline Regulations	May 9, 1990
Mirex Regulations	November 23, 1978
Ocean Dumping Regulations	1975
Ozone-Depleting Substances Regulations No.1 (CFCs)	June 29, 1989
Ozone-Depleting Substances Regulations No.2 (certain BFCs)	August 28, 1990
Ozone-Depleting Substances Regulations No.3 (products)	August 28, 1990
Ozone-Depleting Substances Regulations No. 4 (Methyl Chloroform and Carbon Tetrachloride)	August 27, 1993
PCB Waste Export Regulations	July 27, 1990
Petroleum Refinery Effluent Regulations	..
Phosphorus Concentration Regulations	..
Polybrominated Biphenyls Regulations	February 15, 1990
Polychlorinated Terphenyls Regulations	February 15, 1990
Pulp and Paper Mill Defoamer and Wood Chip Regulations	May 7, 1992
Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans regulations	May 7, 1992
Secondary Lead Smelter Release Regulations	February 21, 1991
Storage of PCB Material Regulations	August 27, 1992
Toxic Substances Export Notification Regulations	November 12, 1992
Vinyl Chloride Regulations	April 11, 1979
Fisheries Act	
Alice Arm Tailings Deposit Regulations	..
Chlor-Alkali Mercury Liquid Effluent Regulations	April 10, 1979
Meat and Poultry Products Plant Liquid Effluent Regulations	..
Metal Mining Liquid Effluent Regulations	..
Petroleum Refinery Effluent Regulations	February 25, 1977
Port Alberni Pulp and Paper Effluent Regulations	..
Potato Processing Plant Liquid Effluent Regulations	November 12,1992
Pulp and Paper Effluent Regulations	..
International River Improvements Act	May 7, 1992
International River Improvements Regulations	..
Weather Modification Information Act	
Weather Modification Information Regulations	..

Source:
Environment Canada, 1993.

the percentage of PAC investments compared to total investments remained steady. This percentage increased from 1.5% in 1985 to 12.6% in 1991, and remained near that level until 1993 despite the recession (Table 3.4).

The majority of these investments are in pollution abatement and control equipment. They represented between 65% and 93% of the industry's PAC investments over the 1985 to 1993 period.

In December 1990, British Columbia adopted pulp and paper mill effluent regulations. The primary goal of the regulations was mainly to reduce furan and dioxin contamination.[1] They mainly targeted mills not yet performing at an acceptable level. The mills had to improve their production processes to reduce pollution, and those not yet equipped with wastewater treatment systems had to install such systems.

In January 1992, the legislation was amended and stricter measures with respect to dioxins and furans in British Columbia's water were introduced. The amendment required pulp and paper mills to completely eliminate furan and dioxin emissions by the year 2002. In 1993, Ontario also adopted environmental regulations aimed at eliminating dioxin and furan emissions by the year 2002.

Overall, the purpose of these federal and provincial measures is to reduce dioxin and furan emissions, and improve the paper bleaching process. Quebec adopted a regulation aimed at reducing by 75% the biochemical oxygen demand

1. In laboratory tests, dioxin causes death in rainbow trout at concentrations above 40 parts per quadrillion. Together, furans and dioxins form a family of chemical compounds, some of which have been shown to be extremely toxic in laboratory animals.

Table 3.2
PAC Investments, 1985-1993

	1985	1986	1987	1988	1989	1990	1991	1992	1993
					thousand dollars				
Industrial and commercial construction	50 889	50 090	94 699	255 474	309 319	503 326	614 486	686 030	686 298
General machinery and equipment	89 676	142 920	129 456	231 274	475 008	762 608	625 619	559 228	394 529
Total	**140 565**	**193 010**	**224 155**	**486 748**	**784 327**	**1 265 934**	**1 240 105**	**1 245 258**	**1 080 827**

Note:
Ontario Hydro's and Nova Scotia Hydro's capital expenditures are combined under "Industrial and commercial construction".
Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

(the amount of dissolved oxygen required for bacterial decomposition of organic wastes in water), and which imposes a reduction in waste toxicity. The initial application deadline was established as December 31, 1993, with a second deadline established as December 31, 1996.

The primary metals industry

Growth in total investments in the primary metal industry in the late 1980s was much slower than that of the paper and allied products industry. Total investments decreased by over 60% during the recession. The percentage of those investments allocated to pollution abatement and control assets was slightly higher than for the paper and allied products industry in the mid 1980s (Table 3.4).

However, from 1990 to 1993, this percentage was similar to that observed in the paper and allied products industry, at between 11% to 14%. The two main assets are pollution abatement and control equipment and construction. These assets accounted for approximately 95% of all pollution control investments. The only exception was 1993, when the asset item "sewage treatment and disposal plants including pumping stations" accounted for approximately one-third of pollution abatement and control investments.

The primary metals industry invested heavily in pollution abatement and control equipment between 1989 and 1992, spending some $400 million in 1990 (Figure 3.2). Most of these expenditures were made in the context of the federal-provincial agreement to reduce sulphur dioxide emissions, which targets smelters and electrical power plants in Eastern Canada. The objective established for the four largest Ontario producers was to reduce sulphur dioxide emissions, which were over 1 million tonnes in 1990, by 50% from 1990 to 1994.

The chemical and chemical products industry

Investments made by the chemicals industry are more stable than those of the paper and allied products and primary metals industries (Figure 3.3). Nevertheless, the percentage of those PAC investments varied somewhat from one year to the next (fluctuating between 1% and 8%). This percentage reached approximately 5% in 1993, compared to 11% for primary metals and 13% for paper and allied products (Table 3.4).

In 1993, the members of the Canadian Chemical Manufacturers Association reduced chemical emissions from pro-

Table 3.3
PAC Investments by Industry, 1985-1993

Industry	1985	1986	1987	1988	1989	1990	1991	1992	1993
					thousand dollars				
Forestry	x	-	-	72	x	x	740	x	x
Mines	..	..	40 814	87 796	51 829	78 015	71 455	64 350	58 134
Food and beverages	x	x	12 846	4 973	x	x	9 724	33 501	15 149
Paper and allied products	31 204	35 671	37 759	95 394	171 625	489 810	400 052	278 539	281 795
Primary metals	54 511	57 721	73 419	121 427	258 519	395 750	259 860	198 926	107 483
Fabricated metal products	4 852	7 451	7 482	7 844	10 843	6 008	x	x	x
Transportation equipment	1 977	19 553	5 194	16 288	15 464	14 037	15 695	1 870	10 450
Non-metallic mineral products	2 536	3 693	x	3 287	4 137	1 568	x	x	x
Refined petroleum and coal products	1 236	x	3 028	3 201	x	12 699	17 935	16 423	22 955
Chemical and chemical products	11 642	31 448	24 120	31 122	123 991	29 081	37 777	68 967	77 388
Other manufacturing industries	3 139	10 830	7 004	9 340	20 843	26 817	26 329	23 153	14 301
Electricity, gas and other utilities	x	2 503	x	64 885	99 346	177 033	378 119	504 779	457 659
Other non-manufacturing industries	19 499	18 301	8 350	41 119	9 463	9 846	15 172	49 372	26 627
Total	**140 565** [1]	**193 010** [1]	**224 155**	**486 748**	**784 327**	**1 265 934**	**1 240 105**	**1 245 258**	**1 080 827**

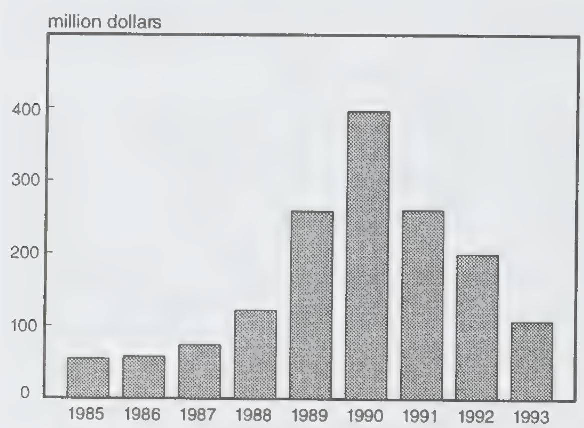
Note:
1. The totals prior to 1987 do not include the mining industry.
Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

Table 3.4
PAC Investments as a Proportion of Total Investments, 1985-1993

Industry	1985	1986	1987	1988	1989	1990	1991	1992	1993
	percent								
Forestry	-	-	-	-	-	x	0.6	x	x
Mines	..	..	3.9	5.9	3.9	7.2	8.9	4.5	3.7
Food and beverages	x	x	1.1	0.4	x	x	0.7	2.1	1.1
Paper and allied products	1.5	1.8	1.5	2.6	3.1	11.4	12.6	10.3	12.6
Primary metals	3.4	3.3	4.9	7.9	11.0	13.6	10.6	13.9	10.7
Fabricated metal products	0.8	1.0	1.6	1.7	2.6	1.8	x	x	x
Transportation equipment	0.2	0.7	0.2	0.6	0.6	0.9	0.8	0.1	0.3
Non-metallic mineral products	1.1	1.1	x	0.7	0.7	0.3	x	x	x
Refined petroleum and coal products	0.4	x	0.5	0.5	x	1.3	1.8	2.6	5.8
Chemical and chemical products	1.3	2.7	2.2	2.7	7.6	1.6	2.0	4.1	4.5
Electricity, gas and other utilities	x	x	x	0.6	0.9	1.5	3.0	17.1	13.9

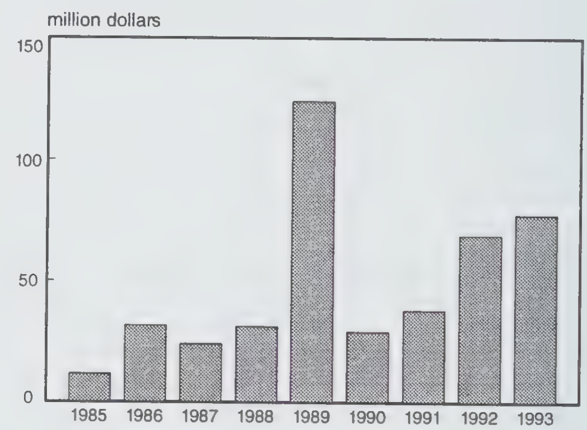
Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

Figure 3.2
PAC Investment in the Primary Metals Industry, 1985-1993



Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

Figure 3.3
PAC Investment in the Chemical and Chemical Products Industry, 1985-1993



Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

duction by 20% compared to 1992, as part of the industry's environmental initiative (Canadian Chemical Manufacturers Association, 1993)

The mining industry

The mining industry was not fully covered by the *Capital Expenditures Survey* by asset category until 1987. Since then, this industry has accounted for a considerable proportion of total PAC expenditures. In 1987, the industry invested $40.8 million in PAC (Table 3.3), or close to 4% of its total capital expenditures. This percentage peaked in 1991, when almost 9% of all capital investments were capital PAC expenditures (Table 3.4).

Electricity, gas and other utilities

PAC expenditures in this industry reached very high levels after 1988. Ontario Hydro's impact is significant: with $177 million in PAC expenditures in 1990, the industry's percentage of total PAC investments reached 14%. Ontario Hydro's expenditures had increased the industry's share of total PAC expenditures to 40% by 1993 (Table 3.3).

The Point Aconi plant in Nova Scotia, in operation since 1994, is an example of the type of expenditures made in this industry. The plant, with a total capacity of 165 megawatts, burns coal, using a more "environmentally friendly" process. The process produces 90% less sulphur dioxide emissions and over 65% less nitrogen oxide emissions than traditional plants (Environmental Digest, 1993).

Table 3.5
PAC Investments by Province and Territory, 1985-1993

Province/Territory	1985	1986	1987	1988	1989	1990	1991	1992	1993
					thousand dollars				
Newfoundland	x	2 628	9 266	x	x	20 242	x	x	x
Prince Edward Island	x	x	x	x	x	x	x	x	x
Nova Scotia	x	6 397	x	9 721	x	6 112	x	x	18 183
New Brunswick	1 935	3 288	11 825	25 333	13 105	9 408	x	78 417	31 085
Quebec	55 206	48 000	69 677	85 657	195 027	255 859	121 516	159 530	163 260
Ontario	59 421	106 981	84 809	226 230	386 824	501 272	678 566	577 388	481 893
Manitoba	x	1 677	3 072	14 183	10 703	x	5 566	12 298	18 209
Saskatchewan	353	1 556	3 487	5 865	8 161	x	24 219	x	x
Alberta	9 794	15 462	7 773	23 641	44 118	25 394	24 611	84 570	128 752
British Columbia	3 386	6 943	25 160	73 440	113 351	399 510	327 910	212 559	205 955
Yukon	x	x	x	102	x	2 231	x	x	x
North West Territories	x	x	6 482	15 991	1 423	7 080	1 351	x	571
Canada	**140 565**	**193 010**	**224 155**	**486 748**	**784 327**	**1 265 930**	**1 240 110**	**1 245 260**	**1 080 830**

Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

During the 1970s, the demand for electricity was increasing and acid-gas emissions peaked in 1982 at 531 thousand tonnes. At that point, the Ontario government began regulating these emissions. Between 1982 and 1990, Ontario Hydro reduced its emissions by 50%. This decrease continued into the early 1990s due to the imposition of a limit of 280 thousand tonnes for the years 1990-1993 and 215 thousand tonnes in 1994.

Results by province

The Atlantic provinces account for a relatively low proportion of pollution abatement and control capital expenditures. However, from 1985 to 1993, this percentage increased from 3% to 10% of total PAC expenditures (Table 3.5). In 1985, Quebec accounted for 39% of private-sector PAC investments. After 1986, this percentage dropped to 25% of private-sector investments and subsequently fluctuated between 10% and 25% of the national total. Ontario accounted for 40% to 60% of private-sector PAC investments. The British Columbia situation is interesting because in 1985, it accounted for only 2% of Canada's private-sector PAC investments and in 1990 was 32%, subsequently falling to approximately 19%. This result is largely due to paper and allied products industry investments.

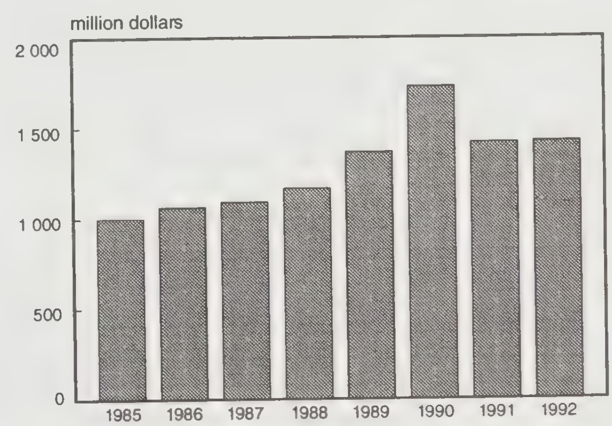
The public and private sectors in contrast

Although analysis of public-sector environmental expenditures is not the purpose of this study, it is interesting to note certain differences between private-sector and public-sector data. Governments invest mainly in anti-pollution activities, waste treatment facilities, sewer systems and sanitation equipment. These investments grew at an average rate of 6% per year between 1985 and 1992 (Figure 3.4). In comparison, there was an annual average increase of 29% in private-sector investments for the same period. In 1985, only 13% of PAC investments were made by the private sector. In 1989 and 1990, approximately 40% of PAC investments came from the private sector (Figure 3.5).

Methodology

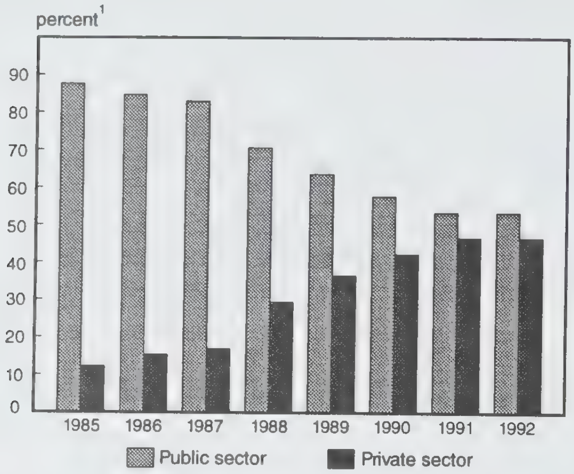
The data used in this article are from Statistics Canada's annual *Capital Expenditures Survey*. The survey is not specifically designed to assess environmental expenditures by companies but rather to estimate expenditures made by companies for certain assets. Some of those assets were considered to be PAC-related assets (Text Box 3.1). How-

Figure 3.4
Public-sector PAC Investments, 1985-1992



Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division.

Figure 3.5
Public and Private-sector PAC Investment, 1985-1992



Note:
1. Public or private PAC investment as a proportion of total PAC investment.
Sources:
Statistics Canada, Investment and Capital Stock Division and National Accounts and Environment Division

ever, some activities may fall within a category of assets deemed non-environmental but which have an environmental purpose (purchase of a ventilator, for example). These were not included as PAC expenditures. The expenditures assessed in this study are therefore assessed on the basis of a lower limit of environmental expenditures by companies.

Another Statistics Canada survey for the year 1989 asked respondents to indicate their PAC capital expenditures. The *1989 Pollution Abatement and Control Survey* estimated private-sector PAC expenditures at $1.1 billion, which is 40% higher than expenditures in the *Capital Expenditures Survey*. This difference can be explained by the nature of the 1989 survey. That survey specifically asked respondents to estimate their PAC expenditures. In such a case, one might expect to obtain higher expenditures than for a survey whose objective is to measure total capital expenditures per asset category, and for which PAC expenditures are estimated on the basis of the asset category data.

Conclusion

For several industries, pollution abatement and control capital expenditures have increased both in absolute terms and as a percentage of their total investments since the late 1980s. This increase occurred within a context of general public awareness of environmental problems. In addition, stricter regulation of certain industries that pollute was implemented in the early 1990s.

Nonetheless, the ability to interpret pollution abatement and control expenditures is limited. These expenditures represent a minimum value of total PAC expenditures. Several other expenditures cannot be isolated, given the complexity of the environmental decision-making process. Although investments made by companies are a useful indication, the real measure of changes in environmental activity is not the assessment of PAC expenditures, but rather the measurement of the quantities of polluting substances emitted by the industries.

Text Box 3.1
Asset Categories

To estimate capital expenditures, ten categories of assets specified in the *Capital Expenditures Survey* were used:

Industrial and commercial construction

- pollution abatement and control;
- waste disposal facilities;
- sewage treatment and disposal plants including pumping stations;
- sanitary and storm sewers;
- trunk and collection lines, open storm ditches and laterals;
- lagoons;
- other sewage system construction;
- mining residue processing system;

General machinery and equipment

- pollution abatement and control equipment;
- sanitary equipment.

References

Canadian Chemical Producers Association, 1993, *Emissions Reduction - 1993 Emissions Inventory and Quinquennial Projections,* Responsible Care, Ottawa.

Environmental Digest, 1993, "Point Aconi Station Comes on Line," in Volume 4, No. 21.

Environment Canada, 1993, *Environmental Protection Regulatory Review: Discussion Document*, Office of Regulatory Examination, Ottawa.

Lacroix, Anik, 1995, "Government Expenditures on Environmental Protection," in *Environmental Perspectives 2: Studies and Statistics,* Statistics Canada, Catalogue No. 11-528E, No. 2, Ottawa.

4 Environmental Aspects of Consulting Engineering and Scientific and Technical Services

by Craig Gaston

Until recently, public awareness of environmental issues was negligible. Today, communities, governments and businesses are called upon to act more responsibly towards the environment. This has given rise to a broad spectrum of goods and services which help government and business act in an environmentally responsible manner. The producers of these goods and services can be grouped under the general label of the "environment industry" (Text Box 4.1).

The environment industry is not identified as an industry in the Standard Industrial Classification (SIC) since it defines an industry as a group of establishments that produce a narrow and relatively homogenous range of goods or services. Rather, the environment industry consists of a broad range of companies involved in producing a wide variety of goods and services used to monitor, improve and protect the environment. In fact, for some companies, the majority of their production is in goods and services not exclusively used for environmental purposes. As a consequence, these companies are scattered throughout the industry classes of the SIC. Some SIC classes have concentrations of these companies. Such is the case of the two Standard Industrial Classification Industries featured in this chapter: the consulting engineering and the scientific and technical services industries.[1]

The type of environmental service provided by both the consulting engineering firm and the scientific services firm is usually geared to the needs of the client. For example, local government departments and businesses in the waste management industry use the services of these firms in: the selection of landfill sites, managing the incineration of solid and hazardous wastes, managing air and water pollution, the construction and management of transfer stations, the treatment of water and wastewater (physical separation, membrane filtration, etc.), the analysis of trends in waste management, the examination of energy alternatives and the development of environmental technologies for the future. Consulting engineers and scientific technicians are also involved in the development of pollution prevention methodologies, the identification of costs and liabilities of not initiating prevention programs, the assessment of contaminated sites, the clean-up of environmental disasters, the compliance to environmental regulations and the development of federal and provincial environmental regulations.

Text Box 4.1
The Environment Industry

The environment industry is not found as a separate industry in the Standard Industrial Classification (SIC). The structure of SIC reflects the production process and the make-up of the final good or service. It does not classify companies according to the end use of their products or services. In contrast, the environment industry is intended to include companies which produce goods and services which are used for environmental purposes. Membership in the industry is complicated by the fact that the goods and services produced are not exclusively used for environmental purposes - e.g., pumps. There is no official definition of this industry although there is increasing consensus on what types of goods and services should be included. The Organisation for Economic Co-operation and Development (1996) has proposed the following classification for companies producing environmental goods and services:

- waste water treatment equipment;
- waste management and recycling equipment;
- air pollution control equipment;
- noise reduction equipment;
- monitoring instruments, scientific, research and laboratory equipment;
- natural resource conservation/protection and urban amenities;
- waste-water operations;
- waste handling and facility operations;
- noise reduction operations;
- analytical, monitoring and related conservation and protection services;
- technical and engineering services;
- environmental research and development;
- environmental training and education;
- accounting and legal services;
- consulting services;
- other environmental business services;
- other: eco-tourism;
- clean production equipment;
- efficient energy generation and conservation equipment;
- eco-products.

1. Statistics Canada is developing a fuller data base on the environment industry that will provide more current and in-depth information. This project is part of the Environmental Industry Strategy coordinated by Industry Canada and Environment Canada.

Table 4.1
Consulting Engineering Firms: Summary Statistics, 1991

	Environmental specialists	Other firms
Total revenues ($000)	394 514.0	3 083 250.0
Number of employees	3 706.0	36 166.0
Number of firms	65.0	458.0
Revenue per employee ($000)	106.5	85.3
Revenue per firm ($000)	6 069.4	6 732.0
Number of employees per firm	57.0	79.0
Export share of fee income (percent)	8.2	13.5
	percent	
Type of service		
Turnkey projects	0.6	10.3
Environmental advisory services	42.1	2.6
Other advisory services	11.9	13.7
Environmental design services	20.3	3.1
Other design services	11.7	46.6
Construction management	6.7	4.8
Project management services	4.6	9.0
Supplementary services	0.8	2.8
Sale of software products	0.2	0.9
Other	1.3	5.2
Total	**100.0**	**100.0**

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Services, Science and Technology Division.

Consulting engineering services

Consulting engineers provide a variety of services in the planning, design, advisory, construction and management of structures and processes. Consulting engineering firms supply services to almost every sector of the Canadian economy, and the structure of the industry is changing rapidly. In particular, growth is occurring in services that have not traditionally been provided by consulting engineering firms. These areas include, among others, environmental services. This movement has been mainly driven by government legislation to protect the environment and by public concern. Information on consulting engineering firms has been compiled from Statistics Canada's *Survey of Consulting Engineers.*[1]

Firms which specialized in environmental services[2] accounted for over 11% of the fee income of all consulting engineering firms in 1991 and for over 12% of all firms in the survey. Environmental consulting firms tended to be smaller, on average, than their counterparts but their revenues per employee were almost 25% higher than other consulting engineering firms.

Firms specializing in environmental services tended to provide advisory services (42% of fee income) whereas other consulting engineering firms were more inclined to provide design services (47%) (Table 4.1). This reflects the fact that many environmental services are of an advisory nature. In addition, the low percentage of revenues for design services in environmental service companies reflects the difficulty of isolating the environmental aspects of many engineering design projects. For this reason, environmental service revenues and indeed the number of companies specializing in environmental services, may be understated.

Although the occupational composition of the workforce was similar for firms specializing in environmental services and other firms, the percentage of full-time workers was much higher for the former in 1991 (Table 4.2). Other firms relied much more heavily on part-time and contract workers. It should also be noted that firms which specialize in environmental services used relatively more technicians and fewer engineers and other professionals.

Table 4.2
Employment in Consulting Engineering Firms, 1991

	Environmental specialists	Other firms
	percent	
Full-time employees	90.3	78.6
Part-time employees	5.4	13.5
Contract	4.3	7.7
Working owners	-	0.2
Total	**100.0**	**100.0**
Occupation		
Engineers, Professional	30.1	32.2
Engineers, Other	2.3	3.7
Other professionals	6.8	8.4
Technicians and technologists	39.3	33.4
Administrative	18.7	16.8
Other	2.8	5.5
Total	**100.0**	**100.0**

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Services, Science and Technology Division.

In 1991, firms specializing in environmental services earned only 8.2% of their revenues from foreign projects compared to 13.5% for other consulting engineering firms (Table 4.1). Foreign projects carried out by firms specializing in environmental services were largely self-financed or financed from private Canadian sources. This contrasts with the more diverse sources of funding for other consulting engineering firms (Table 4.3).

Scientific and technical services

The scientific and technical services industry supplies a broad range of clients with a wide variety of activities from remote sensing services to the provision of environmental

1. The *Survey of Consulting Engineers* is conducted annually by Statistics Canada. It collects data on over 500 companies.
2. For the purpose of this paper, a firm specializes in environmental services if environmental services were the largest single source of fee income in the year examined and accounted for at least one-third of fee income.

Table 4.3
Source of Financing of Foreign Projects, 1991

Source	Environmental specialists	Other firms
	percent	
CIDA	3.1	16.9
Export Development Corporation	-	8.4
World Bank	-	5.7
Regional development banks	-	1.8
United Nations specialized agencies or programs	-	0.5
Foreign governments	-	11.8
Private foreign source	2.7	29.5
Private Canadian source	24.8	8.9
Self financed	69.3	15.9
Other	0.1	0.6
Total	**100.0**	**100.0**

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Services, Science and Technology Division.

services. Specific environmental services include oceanography, meteorology, climatology, pollution research, laboratory testing and assessment and other environmental services.

The degree of specialization in environmental services within the scientific and technical services industry (STS) was much higher than the specialization within the consulting engineering industry. However, the total contribution to industry income of environmental STS firms was less than 5% in 1991. These firms provide the services listed in Table 4.4. The most important service is pollution and other environmental research, laboratory testing and assessments. Information presented here has been tabulated from Statistics Canada's *Survey of Scientific and Technical Services*.

Table 4.4
Scientific and Technical Services Firms: Summary Statistics, 1991

	Environmental specialists	Other firms
Total revenues ($000)	81 967	1 665 438
Number of employees	974	19 907
Number of firms	27	347
Revenue per employee ($000)	84	84
Revenue per firm ($000)	3 036	4 800
Number of employees per firm	36	57
	percent	
Type of service		
Oceanography	1.3	0.1
Meteorology	0.5	-
Climatology	0.3	-
Pollution and other environmental research, laboratory testing and assessment	39.9	0.3
Other environmental services	46.4	0.2
Other services	11.6	99.4
Total operating revenues	**100.0**	**100.0**

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Services, Science and Technology Division.

Environmental STS firms relied more heavily on professionals than did environmental consulting engineering firms and within the STS industry, environmental specialist firms had relatively more professionals (46%) than other STS firms (37%) (Table 4.5).

Employee remuneration costs tended to be relatively higher for firms specializing in environmental services (53% of total

Table 4.5
Employment in Scientific and Technical Services Firms, 1991

	Environmental specialists	Other firms
	percent	
Full-time employees	82.4	80.5
Part-time employees	6.0	10.6
Contract	11.6	8.8
Working owners	-	0.2
Total	**100.0**	**100.0**
Occupation		
Professionals	46.2	36.9
Technicians	35.4	35.0
Administrative support	15.7	16.4
Other	2.7	11.4
Total	**100.0**	**100.0**

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Services, Science and Technology Division.

expenses compared to 47%), possibly a result of the higher percentage of professionals in these firms. This difference was offset mainly by relatively lower share of materials and supplies and depreciation costs.

The distribution of revenues according to the industry of the client is a characteristic that distinguishes environmental specialists from the rest of the STS industry. The former earned 29% of their operating revenues from services to governments whereas the latter earned only 14% from this source in 1991 (Table 4.6).

Table 4.6
Source of Revenues of Scientific and Technical Services Firms, 1991

	Environmental specialists	Other firms
	percent	
Governments	28.6	14.0
Private sector	58.7	72.8
Individuals	1.7	1.8
Foreign	10.9	11.3
Total	**100.0**	**100.0**

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, National Accounts and Environment Division and Services, Science and Technology Division.

Conclusion

This brief review shows that environmental revenues were a small but important part of the consulting engineering industry and a very minor part of the scientific and technical services industry in 1991. An analysis of the period 1989-1994 is under way.

Reference

Organisation for Economic Co-operation and Development, 1996, *The Global Environmental Goods and Services Industry*, Paris.

5 Households and the Environment: Canada and Australia

by Bruce Mitchell

Introduction

Canada and Australia, despite being at opposite ends of the earth, share many common characteristics of culture, economy, geography and environment.

Canada and Australia are large countries with small populations. In each country those populations are locally concentrated with the great intervening expanses having few residents. The distances have shaped the evolution of social and economic interactions and the nature of transportation systems. The automobile, for example, plays an important part in the daily lives of many citizens of each country.

Both nations have European origins overlaid on a base of native aboriginal cultures. Multicultural influences in recent years have brought about major socio-cultural changes. Each country has the good fortune to be well endowed with a variety of natural assets including metals, hydro-carbons, forests, and fertile soils.The economies of Canada and Australia have traditionally been based on the extraction of natural resources and on agriculture. Strong manufacturing sectors utilising highly skilled labour forces developed to serve growing domestic and export markets by the mid part of this century. In each country the manufacturing sector has been under pressure lately in the face of strong international competition.

Environmental influences play a strong role in shaping activities in each country. In Canada, cold, snowy winters affect most things Canadians do and limit activities for much of the year. In Australia the limited availability of water in many areas and the frequent periods of drought have influenced the behaviours of farmers and other householders, as well as the patterns of settlement.

In both Canada and Australia, the natural environment[1] has a relatively high public profile. It appears frequently in art, literature and popular culture. In addition, environmental topics appear prominently in the curricula of Canadian and Australian schools. This widespread interest is also reflected in the degree of participation in environmentally related activities - as revealed by relevant surveys taken in each country.

In recent years, Statistics Canada and the Australian Bureau of Statistics have each undertaken new household surveys on the environment. These surveys look at some aspects of household facilities, products and behaviours that are considered to be relevant from an environmental perspective.

In each case, the survey was conducted as a supplement to the labour force activity survey of the population.[2] Environment surveys were conducted in Canada in May 1991 and May 1994. The Australian Bureau of Statistics ran environment surveys in May 1992 and June 1994.

Data are also collected in other surveys that provide useful information for environmental analysis. For example, a number of measures on energy use around the home that are collected by the Australian environment survey are gathered by the *Household Facilities and Equipment Survey* in Canada.

The purpose of this chapter is to examine the environmentally relevant behaviours of Canadian and Australian households, highlighting the many similarities as well as the differences that are the result of the unique environmental conditions present in the two countries.

The surveys themselves have enough commonality in terms of the questions asked, methodology, and sampling that comparisons are judged to be reasonable. Nevertheless, the reader is urged to remember that the data presented here were not collected using exactly the same procedures and were not originally intended to be compared. Caution in interpreting the results is advised.

The subjects covered in this paper include the 1) use of energy and selected energy intensive appliances around the home, 2) water use, and 3) waste management practices.

Energy use

Australia and Canada share the distinction of being among the largest per capita users of energy in the world. Among the 25 member countries of the Organisation for Economic Co-operation and Development (OECD) for 1993, Canada was the third highest consumer of energy[3] at 5.84 tonnes of oil equivalent per capita and Australia was tenth at 3.55 tonnes per capita (OECD, 1995a; p. 199, 283). These figures are influenced by the industrial economies and the small populations of each country. However, lifestyle considerations also come into play. Space heating and cooling,

1. Especially wilderness areas such as the Arctic and boreal forests in Canada and the Outback in Australia.

2. Titled the *Labour Force Survey* in Canada and the *Survey of Population* in Australia, these are sample surveys that regularly measure labour force participation.

3. Final consumption of energy. This is the end use sector's consumption and excludes energy used for own use by energy producing industries and for transformation.

household appliances, and motor vehicles are the major elements of the energy consumption by households.

Table 5.1 presents per capita information for OECD countries on the final consumption of energy, the use of motor gasoline and residential energy use.

Table 5.1
Energy Consumption Measures for Canada, Australia and Other OECD Countries, 1993

Country	Population	Final consumption of energy	Motor gasoline use	Residential energy use
	thousands	tonnes of oil equivalent per person		
Luxembourg[1]	395	9.25	1.42	1.40
Iceland[2]	262	6.87	0.54	2.39
Canada	**28 947**	**5.84**	**0.92**	**1.05**
United States	257 908	5.45	1.29	0.96
Finland	5 066	4.58	0.39	1.02
Norway	4 312	4.25	0.41	0.84
Sweden	8 718	3.93	0.51	0.95
Belgium	10 084	3.61	0.30	0.89
Netherlands	15 300	3.60	0.26	0.68
Australia	**17 657**	**3.55**	**0.76**	**0.45**
New Zealand	3 480	3.07	0.58	0.34
Germany	81 190	3.00	0.41	0.76
Denmark	5 189	2.89	0.38	0.88
Austria	7 991	2.83	0.34	1.05
France	57 667	2.64	0.31	0.42
United Kingdom	58 191	2.61	0.44	0.71
Japan	124 670	2.54	0.30	0.36
Ireland	3 560	2.22	0.29	0.55
Italy	57 070	2.13	0.30	0.56
Spain	39 083	1.61	0.24	0.20
Greece	10 368	1.49	0.27	0.28
Portugal	9 887	1.36	0.19	0.18
Mexico	91 210	1.11	0.26	0.20
Turkey	59 490	0.80	0.07	0.27

Notes:
1. Luxembourg's taxes on certain fuels are lower than in surrounding countries. This may be a factor involved in the apparently high per capita consumption rates.
2. Iceland includes geothermal power in the residential energy figures.
Sources:
OECD, 1995a, 1995b and 1995c.

Characteristics of climate in Australia and Canada lead to high levels of residential energy consumption. Necessity demands that extreme temperatures be moderated to allow people to survive, but our affluent lifestyles demand comfort over and above this. In the case of indoor temperatures, this means achieving a degree of stability year-round as afforded by efficient heating and cooling systems.

As Table 5.1 illustrates, Canada's per capita residential consumption of energy[1] is relatively high. This level of use also occurs in a number of cold climate countries including Finland, Sweden and the United States.

Compared to Canada's residential energy use per capita figure of 1.05 tonnes of oil equivalent per person, Australia's figure of 0.45 tonnes per person is modest. However, the Australian number exceeds that of all the other OECD countries with similar climates, Portugal, Spain, Turkey, and Greece. The Australian figure is also higher than several countries with cooler climates, including Japan, France and New Zealand.

All Canadian households and most Australian ones use some form of heating during the winter months. The colder Canadian winter sees Canadians consuming more energy per capita than Australians for space heating. However, in the parts of Australia with the lowest average winter temperatures, highland New South Wales and Victoria, the Australian Capital Territory (A.C.T.) and Tasmania, household heating requirements in winter probably approach the levels required in the mildest part of Canada[2].

In the summer months, periods of extreme heat are common in much of Australia and in many parts of Canada and air conditioning systems are used by many households in these areas.

Table 5.2
Heating and Cooling in Dwellings, 1994

	Canada	Australia
	percent	
Heating available in dwellings	100.0	83.8
Principal form of heating for heated dwellings		
Piped and bottled gas	47.5	38.0
Electricity	33.0	35.5
Oil	14.5	3.7
Wood	4.7	21.0
Other	0.3	1.8
Air conditioning in dwellings	26.8	32.5

Sources:
Statistics Canada, 1995a.
Australian Bureau of Statistics, 1995.

One hundred percent of Canadian homes had a source of space heating in 1994 while the figure for Australia was 83.8% (Table 5.2). However in the temperate Australian States of Victoria and Tasmania it was 99.4% and 99.8% respectively and 99.6% in the A.C.T. On the other hand, only 19.2% of dwellings in the tropical Northern Territory had some form of heating.

Some form of air conditioning was available in 32.5% of Australian homes while in Canada the figure was 26.8% in 1994. Again, there are regional variations related to climate. Ontario's hot, humid summers contribute to the fact that 48.1% of the province's homes had air conditioners. In the Northern Territory of Australia 76.4% of homes had air conditioning. Areas that have hot, but less humid summers, have lower levels of air conditioner ownership in both countries. For example, in the Australian Capital Territory only 16.7% of homes had air conditioners while in Alberta air conditioners were present in only 8.2% of homes.[3]

1. The residential consumption figures include all residential use of energy for space heating, space cooling, water heating, operation of appliances and lighting. They do not include energy used in the operation of motor vehicles; these figures are presented separately.

2. The southern coast of British Columbia.

3. The average mid-summer maximum temperature in Medicine Hat, Alberta is 26°C, 23°C in Calgary, and 28°C in Canberra in the A.C.T. Both Medicine Hat and Canberra have experienced extreme maximum temperatures of 42°C; however high humidity rarely accompanies the summer heat.

In both countries motor vehicles are major contributors to high per capita levels of energy consumption. In the face of low population densities in rural areas and relatively low urban densities especially in post-war suburbs, the automobile has been perceived to be the most efficient means of transportation in each country and a necessity for many households. Growing affluence in each country in the post WWII period has been accompanied by an increasing proportion of automobiles per capita.[1]

Table 5.1 presents consumption of motor vehicle gasoline[2] on a per capita basis[3] for a number of OECD countries. Among the countries presented, Canada and Australia rank third and fourth respectively behind Luxembourg and the United States.

Canada and Australia are also among the leaders in terms of passenger vehicles in use per capita. Canada has 470 vehicles per thousand persons while the Australian figure is 460. While Canada and Australia trail the United States in this regard (570 vehicles per thousand people), they lead all other OECD members including France (420 vehicles per thousand persons), Sweden (410 vehicles per thousand persons), the United Kingdom (350 vehicles per thousand persons) and Japan (330 vehicles per thousand persons) (OECD, 1995a; p. 217, 283).

Household appliances are also major consumers of residential energy. Table 5.3 illustrates the degree to which a number of energy intensive home appliances are present in Canadian and Australian households. Refrigerators are practically universal items in the households of each country. Additional fridges are also present in many homes. Freezers are also popular in both countries. About 45% of Australian households have freezers while the number is higher in Canada, at about 59%.

Washing machines are present in 79% of Canadian homes and 94% of Australian ones. Energy used in washing machines is dependent on the style of the machine (front vs. top loading) as well as the temperature of the water used in the washing and rinsing.

Clothes dryers are found in three out of four Canadian households while the number is about one out of two households in Australia. The difficulty of drying clothes outside in Canadian winters is probably a factor contributing to the difference.

Table 5.3
Households with Appliances, 1994

	Canada	Australia
	percent	
Refrigerators	99.4	99.7
Two or more refrigerators	19.4	23.9
Freezers	58.8	44.9
Dishwashers	46.4	25.1
Clothes dryers	75.4	51.7
Washing machines	79.3	94.2

Sources:
Statistics Canada, 1995b; p. 18.
Australian Bureau of Statistics, 1995; p. 46.

Dishwashers use energy not only to operate the motor and pump but also to heat the water and dry the dishes. Automatic dishwashers are somewhat more popular in Canadian households than Australian ones. Forty-six percent of Canadian homes have dishwashers compared to 25% of Australian homes.

Water use

The amounts of water used by residential activities are usually relatively small when compared to uses by agriculture and industry. For example, in 1991 in Canada (Johnson, 1995) only 7% of total water withdrawals were for domestic use while agriculture, manufacturing and thermal power generation accounted for 88% of withdrawals. Only 11% of the water withdrawn came from municipal sources, the rest was self supplied. However, because water must meet high standards of quality to be usable for human consumption, most of the water used for domestic purposes comes from municipal sources and more than half of the treated water produced by municipalities is used by the personal sector (54.8%).

In Australia, figures available for 1987[4] indicate that domestic use accounted for about 7% of total water use (Australian Water Resources Council, 1987).

Water conservation at the household level is an issue both because of overall limitations of water availability in Australia and Canada[5] and because increases in demand require the expansion of water and sewage treatment capacity.

According to Environment Canada estimates, about 75% of water used in the home is for bathroom and toilet use, 20% is used for laundry and 5% for cooking and drinking. Watering lawns and gardens would have a significant seasonal impact on these figures. In Australia, for example, an esti-

1. The number of passenger vehicles per thousand persons in Canada increased from 140 in 1950 to 230 in 1960 and to 420 in 1980. In 1993 there were 470 passenger vehicles per 1000 persons. In Australia there were 90 passenger vehicles per thousand people in 1950, 190 in 1960, 400 in 1980 and 460 in 1993.
2. Diesel is also used to fuel private and commercial vehicles. In some European countries, diesel is somewhat more popular for private vehicles than in Canada or Australia. In Canada 0.21 tonnes oil equivalent (toe) of diesel per capita were used in 1993. This is about the same as the figures for the United Kingdom, Sweden, Ireland and Japan. In Australia, 0.26 toe of diesel per capita were used in the same year. In Germany the figure was 0.27, in France 0.31 and in Belgium 0.39 toe diesel per capita were used (OECD, 1995a).
3. It should be noted that this figure covers all gasoline consumption by motor vehicles and will therefore include a portion of commercial use as well as amounts used by households.
4. Because the Australian and Canadian estimates of domestic water consumption were developed independently using different methodologies, caution should be used in any comparisons of the numbers.
5. Although this is more of a concern in Australia, parts of Canada, the southern Prairies in particular, often face shortfalls in water availability due to low flow rates in rivers and limitations of groundwater supplies.

mated 55% of the total household water consumed by Canberra households is used outside around the home. In Melbourne the figure is 38% while in Perth it is 42% (CSIRO, 1992).

Water conservation practices at the household level in both Canada and Australia are targeted at the more efficient use of water in the bathroom, laundry and around the home.

Conventional North American toilets use about 18 litres of water per flush and are major household water users. Significant savings in water can be made by reducing the amount of water that toilets use. This can be done by modifying the water volume held in the tank of the existing toilet (by adding an object to displace water, a brick in a plastic container, for example) or by installing a toilet that uses less water in the first place. Some of the new low flush models use as little as 6 litres of water.

In several Australian States new toilets installed must be of the low or dual-flush[1] type. Consequently the *1994 Australian Environment Survey* found that 39% of households in Australia have dual flush toilets, with the percentage reaching 51% in the State of Victoria and 48% in South Australia. In addition, 2% of Australian households reported adding an object to the toilet tank to reduce flows in that way.

In Canada, the degree of adoption of this water saving technology is more modest.[2] As Table 5.4 shows, the *1994 Household Environment Survey* found that 15% of Canadian households had a low-flow toilet or had made modifications to the tank to reduce the flow. Alberta households have the highest rate of use of these items at 21%.

Water use for bathing can be reduced in several ways including taking shorter showers or using less water in the bath tub. Another way is to reduce the flow rate of the shower by using a low-flow showerhead. A typical showerhead uses about 20 litres of water a minute (Australian Bureau of Statistics, 1995; p. 75). Low-flow showerheads can reduce the flow down as low as 7 litres per minute while still maintaining a degree of washing efficiency. In addition, by reducing the amount of hot water consumed, low-flow showerheads also reduce the energy used to heat water.

In Australia, about 22% of households use low flow showerheads with the figure being highest in the Australian Capital Territory at about 29%.

In Canada the figure is somewhat higher with 42% of households reporting low-flow showerheads. The energy saving aspect of low-flow showerheads has been promoted widely by some Canadian energy suppliers.

Because water-use concerns have a high profile in Australia, the Australian Bureau of Statistics environment survey asked additional questions that have not been asked in the Canadian survey. For example, 13% of Australian households said they reuse or recycle water, 15% said they used a suds saver on the washing machine, 8% had timers installed on garden taps, and 53% used mulch on garden beds to reduce the need for watering. In summary, 45.7% of households said they used some method of conserving water in the dwelling while 84.1% of households with gardens said they used at least one water conservation measure in the garden.

1. Dual flush toilets have dual controls and allow the user to choose between a moderate or a low volume flush.
2. The building code in Ontario now requires that newly installed toilets must be low volume ones.

Table 5.4
Water Saving Technology in Households, 1994

	Low-flush toilet or object in tank	Low-flow showerheads
	percent	
Canada	**14.8**	**42.3**
Newfoundland	6.0	27.9
P.E.I.	--	33.3
Nova Scotia	12.6	40.7
New Brunswick	11.4	42.4
Quebec	8.7	46.0
Ontario	18.0	44.9
Manitoba	19.4	34.0
Saskatchewan	12.5	26.6
Alberta	20.6	32.2
British Columbia	15.9	43.4
Australia	**40.8**	**21.8**
New South Wales	32.8	19.5
Victoria	51.9	21.2
Queensland	32.9	22.5
South Australia	49.8	26.1
Western Australia	48.8	26.1
Tasmania	32.8	20.6
Northern Territory	--	14.6
A.C.T.	35.7	28.6

Sources:
Statistics Canada, 1995a.
Australian Bureau of Statistics, 1995.

Waste management practices

The consumer orientation of Canadian and Australian societies is reflected by the high levels of household waste generated. Household waste statistics collected in Canada and Australia are not strictly comparable, however estimates produced by the OECD place the two countries among the top per capita generators of municipal waste (OECD, 1995a; p. 151).

In response to environmental concerns and the difficulty of developing new disposal sites, local governments in both Canada and Australia have been active in developing recycling programs to reduce the amounts of municipal waste that is ultimately sent for disposal.

Canadian and Australian household waste management practices are difficult to compare because the questions and definitions used in Canadian and Australian household environmental surveys are slightly different. In addition, the Australian survey rotates the subjects examined from sur-

Table 5.5

Access to, and Use of Services for Paper Recycling by Canadian Households, 1991 and 1994

	Access to program		Use program where available[1]		Households recycling paper[2]	
	1991	1994	1991	1994	1991	1994
	percent					
Canada	**52.6**	**69.6**	**85.8**	**83.1**	**45.2**	**57.9**
Newfoundland	11.3	19.7	--	44.4	--	33.3
P.E.I.	10.6	20.8	--	70.0	--	--
Nova Scotia	36.8	50.3	70.0	72.5	25.8	36.4
New Brunswick	17.5	46.7	65.9	58.8	11.6	27.5
Quebec	33.8	57.2	76.5	74.0	25.9	42.3
Ontario	72.1	83.5	94.5	92.9	68.2	77.6
Manitoba	40.4	61.0	50.3	48.3	20.3	29.5
Saskatchewan	37.6	69.3	69.6	73.2	26.2	50.7
Alberta	51.1	71.2	77.1	75.8	39.4	54.0
British Columbia	64.2	74.5	87.3	88.2	56.1	65.7

Notes:
1. Households reporting use of paper recycling service as a percentage of those with access to the service.
2. Households reporting use of paper recycling service as a percentage of all households.

Sources:
Statistics Canada, 1992 and 1995a.

vey to survey. The 1992 survey contained questions on waste management practices but the 1994 survey did not.

Nevertheless a broad picture of practices and services present does emerge from the data sets that are available. Tables 5.5 and 5.6 present statistics on paper recycling by Canadian and Australian households. Paper is most commonly collected by recycling programs in the two countries and is therefore included in the two tables.

Recycling programs that include paper among the products gathered are now quite common in Canada with almost 70% of households having access to them in 1994, a figure that was up 17% from three years earlier. The relative enthusiasm with which the Canadian public has adopted these programs is reflected in the high participation rates where these services are available.

In Australia as well, participation in paper recycling is popular with 53% of households involved in this activity in 1992. As in Canada, regional availability of services is a major determinant in the level of recycling participation. The numbers range from a high of 67% in the state of Victoria where recycling facilities were widely available at the time of the survey, to 27% in the Northern Territory where they were not as wide spread.

The type of service available probably also has an impact on participation rates. For example, in Ontario curbside recycling is widely available. Compared to neighbourhood or regional recycling depots, curbside recycling demands much less of an effort from the participant so higher participation rates might be expected. In fact Ontario featured the highest rates in Canada in both 1991 and 1994.

Table 5.6

Recycling by Australian Households, 1992

	Paper recycling	No recycling done by the household
	percent	
Australia	**52.8**	**15.6**
New South Wales	57.5	17.3
Victoria	67.1	10.2
Queensland	36.0	19.0
South Australia	43.1	16.7
Western Australia	61.0	12.5
Tasmania	38.4	19.4
Northern Territory	27.1	31.3
A.C.T.	63.3	12.5

Source:
Australian Bureau of Statistics, 1993.

Recycling programs operate most effectively if there is a market for the goods collected. In the case of paper, the products created from the materials collected include paper towels, toilet paper, newsprint, and stationary. For paper towels and toilet paper, especially, advertising on packaging and elsewhere reminds consumers that the products have recycled content and makes the point that these items are "environmentally friendly".

Tables 5.7 and 5.8 present figures on the use of recycled paper in households. Again, readers are advised that because the Australian and Canadian tables are not precisely comparable only general conclusions can be made.

There are only modest regional variations in the use of recycled paper products in both Canada and Australia. In Canada the use of the products increased from 1991 to 1994.

Tables 5.7 and 5.8 also present information on composting, another method to reduce the amount of solid waste disposed. British Columbia, with a milder climate amenable to

Table 5.7

Selected Environmentally Friendly Practices in Canadian Households, 1991 and 1994

	Regularly purchase paper towels and/or toilet paper made from recycled paper		Use a compost heap, compost container or composting service	
	1991	1994	1991	1994
	percent			
Canada	**45.3**	**58.3**	**17.4**	**22.7**
Newfoundland	46.9	68.3	6.2	9.3
P.E.I.	48.9	56.3	10.6	16.7
Nova Scotia	54.0	65.7	16.6	19.0
New Brunswick	50.6	66.3	11.2	16.1
Quebec	38.5	60.7	5.3	7.9
Ontario	51.2	59.9	21.3	30.3
Manitoba	40.9	48.6	15.2	18.1
Saskatchewan	40.7	49.3	20.1	21.6
Alberta	40.6	51.5	17.5	21.2
British Columbia	45.4	53.9	34.9	37.9

Sources:
Statistics Canada, 1992 and 1995a.

Table 5.8
Selected Environmental Practices by Australian Households, 1992

	Use recycled paper products	Compost or mulch
	percent	
Australia	**68.0**	**45.1**
New South Wales	66.4	39.3
Victoria	67.3	48.9
Queensland	67.5	47.5
South Australia	69.9	45.7
Western Australia	73.3	42.2
Tasmania	62.4	53.7
Northern Territory	64.1	44.3
A.C.T.	73.8	50.7

Source:
Australian Bureau of Statistics, 1993.

outdoor activities such as composting, has the largest percentage of Canadian households composting.

As Table 5.8 shows, almost half of Australian households reported that they compost.

Mulching garden beds with composted materials is a popular way of reducing evaporation and thus water use. In 1994 53% of Australian households with gardens reported mulching garden beds to conserve water (Australian Bureau of Statistics, 1995; p. 74).

Conclusion

The data presented in this chapter illustrate many similarities between Australian and Canadian households with respect to their consumption of energy, use of water and management of wastes. The majority of residents in each country have expressed strong support for environmental concerns. For example, the 1994 Australian environment survey found that 69% of Australians were concerned about environmental problems, although this is down from 75% in 1992. In a 1992 survey for Environment Canada, 90% of Canadians said they were at least somewhat concerned about the environment (Statistics Canada, 1995b; p. 63). However, is the commitment to the environment strong when placed in competition with economic concerns and elements of individual lifestyle?

Research in Canada questions the existence of a relationship between the environmental attitudes people express and their actual behaviour to reduce their environmental impacts (Ungar, 1994). The results that have been presented in this paper seem to show that Canadians and Australians are willing to take limited actions that they perceive to be environmentally significant including recycling and doing some things to reduce energy and water use. However, the measures that would have a major impact on resource consumption, for example, a large reduction in motor vehicle use, would also have a major impact on the lifestyles of Canadians and Australians. Would Canadians and Australians be prepared to do more?

References

Australian Bureau of Statistics, 1992, *Australia's Environment, Issues and Facts*, No. 4140.0, Canberra.

_______, 1993, *Environmental Issues, People's Views and Practices, May 1992*, No. 4602.0, Canberra.

_______, 1995, *Environmental Issues, People's Views and Practices, June 1994*, No. 4602.0, Canberra.

Australian Water Resources Council, 1987, *Review of Australia's Resources and Water Use*, A.G.P.S., Canberra.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) – Social Science Unit, Division of Water Resources, 1992, *The Water Future of the ACT, A Community Discussion Document on the Major Issue*, Canberra.

Johnson, Tony, 1995, "Water Use in Economic and Domestic Activity", in *Environmental Perspectives 2 Studies and Statistics,* Statistics Canada, Catalogue No. 11-528E, Ottawa, p. 65-76.

Organisation for Economic Co-operation and Development, 1995a, *OECD Environmental Data Compendium 1995*, Paris.

_______, 1995b, *Energy Statistics of OECD Countries, 1992-1993*, Paris.

_______, 1995c, *Energy Balances of OECD Countries, 1992-1993*, Paris.

Statistics Canada, 1992, *Households and the Environment, 1991*, Catalogue No. 11-526, Ottawa.

_______, 1994, *Household Facilities and Equipment*, Catalogue No. 64-202, Ottawa.

_______, 1995a, *Households and the Environment, 1994*, Catalogue No. 11-526, Ottawa.

_______, 1995b, *Human Activity and the Environment, 1994*, Catalogue No. 11-509E, Ottawa.

Ungar, Sheldon, 1994, "Apples and Oranges: Probing the Attitude-Behaviour Relationship for the Environment", *Canadian Review of Sociology and Anthropology*, volume 31, 3, August.

6 Measuring Canada's Natural Wealth: Why We Need Both Physical and Monetary Accounts[1]

by Alice Born

Introduction

There is growing interest in sustainable development and expanded wealth accounts are seen as a one of the tools in its measurement (see World Bank, 1995 and Hamilton, 1994). Whether it is a measure of wealth per capita or a measure of a nation's total capital over time, wealth accounts and national balance sheets will include the value of natural capital as well as the value of produced capital in the future. Estimation of the value of human capital is still in the early stages of development but the World Bank has recently provided some estimates (World Bank, 1995). The development of natural resource accounts has focused on placing a monetary value on known physical quantities of the resource in order to obtain a wealth value for natural capital.

At Statistics Canada, *Natural Resource Stock Accounts* which are aimed at measuring Canada's natural wealth, are one of four environmental accounts being currently developed. The other three accounts are *Natural Resource Use Accounts*, *Waste Output Accounts* and *Environmental Protection Expenditure Accounts.*[2] The natural resource use and waste output accounts are recorded in physical terms and the environmental protection expenditure accounts, in monetary terms. Only the natural resource stock accounts are recorded in both physical and monetary terms.

This paper reviews some of the preliminary results of the Natural Resource Stock Accounts in the context of Canada's wealth accounts which currently only include the values of produced capital and land. In accordance with the 1993 International System of National Accounts (1993 SNA)[3], Canada plans to add the value of natural wealth (e.g. subsoil and timber assets) to the national balance sheet accounts beginning in 1997. The results presented here are limited to subsoil assets.

The first part of the paper discusses the uncertainty of measuring Canada's resource base and its effects on physical accounting. The second part of the paper focuses on the *linkages* between the physical and monetary accounts, and the 1993 SNA and the System of Economic and Environmental Accounts (United Nations, 1993). Finally, the last part of the paper examines the usefulness of the expanded wealth accounts with respect to the concept of sustainable development.[4] Partial results of Canada's wealth accounts are presented as well.

Physical accounts: resource base and uncertainty

Physical accounting of subsoil assets shows that the assumption of a "fixed and non-renewable" mineral stock can be limiting in determining the size of a nation's resource base. What we observe are "inventories" of proven reserves which are being constantly renewed by investment in exploration and development. Furthermore, in the case of metals, the rate of depletion is impacted by the rate of recycling as well. The size of the resource that is considered "economic" and therefore currently recoverable depends on costs and prices, including the prices of substitutes (Adelman *et al.*, 1991). This suggests that we cannot know how much of mineral resources should be shared with future generations or what is the optimal depletion rate by simply estimating when supplies will be exhausted at current rates of depletion (Mikesell, 1994). Since resource base and reserve estimates are revised from year to year as extraction continues, new discoveries are made and the overall understanding of the resource base improves, physical accounts of fuel and non-fuel minerals should reflect these changes.

Physical accounts should present a range of available resources and not be restricted to only "proven reserves" as suggested by the 1993 SNA. For example, mineral resources can be divided into two components: discovered or known recoverable resources and undiscovered recoverable resources. *Discovered recoverable (or known) resources* are those resources that are estimated to be recoverable from known deposits using current technology and under current economic conditions. Included in this category are: cumulative production,[5] remaining established (or devel-

1. Revised version of a paper presented in Session V: Valuation and Aggregation at the International Association for Research in Income and Wealth Special Conference on Integrated Environmental and Economic Accounting organized by the Economic Planning Agency of Japan, United Nations University and Keio University, Tokyo, Japan, March 5-8, 1996.
2. For a review of natural resource and environmental accounting at Statistics Canada see Smith (1994).
3. Major modifications were made to the System of National Accounts in1993 (United Nations *et al.*, 1993). The balance sheet accounts now include the value of subsoil and other natural assets. The change in the value of these assets is recorded as a reconciliation item and therefore does not affect net product aggregates.
4. Many concepts and definitions of sustainable development are currently being explored and discussed. The concept of sustainability used in this paper suggests that "each generation should maintain the capital value of the natural resources it inherits." In the case of non-renewable resources, this condition can be approximated by saving and reinvesting resource rents from mineral extraction into other forms of capital (Mikesell, 1994).
5. The total amount of hydrocarbon or metal extracted to a given date.

Table 6.1
Energy Resource Estimates, 1992

	Discovered recoverable resources				Undiscovered recoverable resources	Ultimately recoverable resources[2]
	Cumulative production	Remaining established reserves	Yet-to-be established reserves	Total[1]		
Crude oil (millions of m^3)	2 394	680	1 113	4 207 [3]	4 361	8 568 [3]
Crude bitumen[4] (millions of m^3)						
Surface mineable	210	434	9 356	10 000	-	10 000
In situ	59	48	38 893	39 000	-	39 000
Total crude bitumen	269	482	48 249	49 000	-	49 000
Natural gas (billions of m^3)						
Western Canada	2 163	1 909	-	4 072	3 144	7 216
Frontier areas	32	9	1 187	1 228	8 055	9 283
Total	2 195	1 918	1 187	5 300	11 199	16 499
Coal[5,6] (megatonnes)						
Lignite	..	2 236	..	..	..	44 360 [7]
Subbituminous coal	..	871	..	..	..	
Bituminous coal	..	3 471	..	..	..	34 245
Total	..	6 578	..	..	..	78 875
Uranium (kilotonnes)	155 [8]	309	163	627	..	..

Notes:
1. Sum of cumulative production, remaining established reserves and yet-to-be established reserves.
2. Sum of total discovered reserves and undiscovered recoverable resources.
3. Totals in source data.
4. Occurs in oil sands.
5. Reserve definition used is *recoverable* rather than *established*, however the definitions are similar.
6. As of 1985.
7. Lignite plus subbituminous coal.
8. Approximated

Sources:
Natural Resources Canada, 1993a and 1993b.
National Energy Board, 1994.

oped) reserves and yet-to-be established (or undeveloped)[1] reserves. *Undiscovered recoverable resources* are those that are estimated to be recoverable from resources that are believed to exist on the basis of available geological and geophysical evidence but not yet been shown to exist by drilling, testing or production. The sum of discovered and undiscovered mineral resources is referred to as *ultimately recoverable resources* (Table 6.1).

For the purpose of monetary valuation, we focus on that part of the resource base which is estimated to be recoverable using existing machinery and equipment and structures in place, and under current economic conditions. These are defined as *remaining established (*or recoverable) *reserves* in Table 6.1. Established reserves represent a conservative estimate of the available stocks, given changing technology and markets. Nevertheless, based on this definition, it is apparent that rapid depletion has been occurring over a short time period (figures 6.1 to 6.5), particularly for oil and nickel reserves. Yet, these represent only a small portion of Canada's known reserves and ultimately recoverable resources of fossil fuels and metals. In the case of crude oil, remaining established reserves represent 38% of the known reserves and 11% of the total ultimately recoverable resources. For crude bitumen, we are placing a monetary value on only 1% of known reserves and for natural gas, on 62% of known reserves and 13% of the total ultimately recoverable resources.

The importance of physical accounts is demonstrated here. While we are placing a monetary value on only a small part of Canada's known reserves, a large part of the resource remains unvalued. "Option values" based on transaction values might be used to value undeveloped reserves to reflect more closely the total wealth of a nation.[2] A broader definition of resources in the physical accounts shows the resources that are available in the long term.

Physical and monetary accounting

A comprehensive description of the interrelationship between the environment and the economy is not possible without using physical data. In many cases, they are more suitable than monetary data. This is especially true for the flow of materials within the natural environment, and from the natural environment to the economy and back into the environment as wastes (United Nations, 1993). Thus, Statistics Canada's Natural Resource Use and Waste Output Accounts, which are based on input-output models, are expressed in physical terms. Linking those data to the monetary data of the national accounts, however, is necessary for

1. By definition, *developed reserves* are estimated to be recoverable through produced capital already in place (e.g. machinery and equipment and structures). In case of *undeveloped reserves*, additional exploratory and development work would be required in order to classify them as developed reserves.

2. This was suggested by the U.S. Bureau of Economic Analysis (1994).

Table 6.2
Physical and Monetary Assets Accounts

<table>
<tr><th rowspan="2"></th><th rowspan="2">Produced assets</th><th colspan="5">Non-produced assets</th></tr>
<tr><th>Biological resources</th><th>Land (including ecosystems)</th><th>Subsoil assets</th><th>Water</th><th>Air</th></tr>
<tr><td rowspan="2">Physical accounts</td><td rowspan="2">Economically produced</td><td>Economically produced</td><td>Economically used</td><td>Developed reserves</td><td>Economically stored</td><td rowspan="2">Non-economic</td></tr>
<tr><td>Wild</td><td>Uncultivated, protected</td><td>Undeveloped reserves</td><td>Other bodies of water</td></tr>
<tr><td rowspan="2">Monetary valuation</td><td rowspan="2">Market value</td><td>Market value</td><td>Market value</td><td>Market value (developed reserves)</td><td>Market value</td><td rowspan="2">Non-market value</td></tr>
<tr><td>Non-market value</td><td>Non-market value</td><td>"Option values" (undeveloped reserves)</td><td>Non-market value</td></tr>
</table>

the development of other environmental-economic accounting systems.

Table 6.2 compares physical and monetary accounts of produced and non-produced assets. At Statistics Canada, both developed and undeveloped reserves appear in the physical accounts while only developed reserves are valued in the corresponding monetary accounts.

Physical data are difficult or impossible to aggregate across the range of natural resources because of the different statistical units used. Trying to assess the sustainability of an economy or a set of human activities based on inventories of a stock of natural capital also raises the problem of incomparability of physical units. For example, if a stock of timber increases and a stock of natural gas decreases at the same time, how can it be determined if the total stock of natural capital has fallen or risen, or remained the same (Victor, 1990)?

In many cases, the only way to obtain comparable results is to make a monetary valuation. Such a valuation is the norm for produced assets and is necessary to value natural (as well as human) capital in the balance sheet. Using current prices simplifies the valuation of natural capital but can give a distorted view of equilibrium prices in the longer term. In the case of subsoil assets, negative externalities generated by the production of marketed goods, like environmental protection and restoration costs, may not be adequately reflected in market prices.[1] Furthermore, if the price or the net price rises as the resource stock declines, the value of the resource stock as an indicator of sustainability may give the wrong policy signal to government.

Figures 6.1 to 6.5 show the physical quantity of remaining reserves of oil, natural gas, coal, uranium and nickel[2] and the present value of the stocks from 1975 to 1992. While monetary values provide a common numeraire to compare these commodities, the physical quantities sometimes reflect a different picture of the remaining reserves.

Physical quantities of oil reserves have declined almost by half since 1975 while values of the stock increased until 1986 and declined thereafter, reflecting the major drop in world oil prices in that year. Natural gas shows a similar trend to oil, however physical depletion of the stock is less dramatic. Since 1982, coal reserves have been maintained between 6.0 and 6.5 billion tonnes with their present value peaking at $19 billion in 1984 and declining to $13 billion in 1992.[3] Physical reserves of uranium have declined by 200 kilotonnes since 1979 reflecting a price drop from $135 per kilogram[4] in 1980 to $71 per kilogram by 1990. Recent increases in reserves are due to the opening of higher quality mines in Saskatchewan. The changes in present value over time reflect both the price changes discussed above and long-term contracts above world prices for Ontario uranium in the 1980s. Quantities of nickel have been declining since

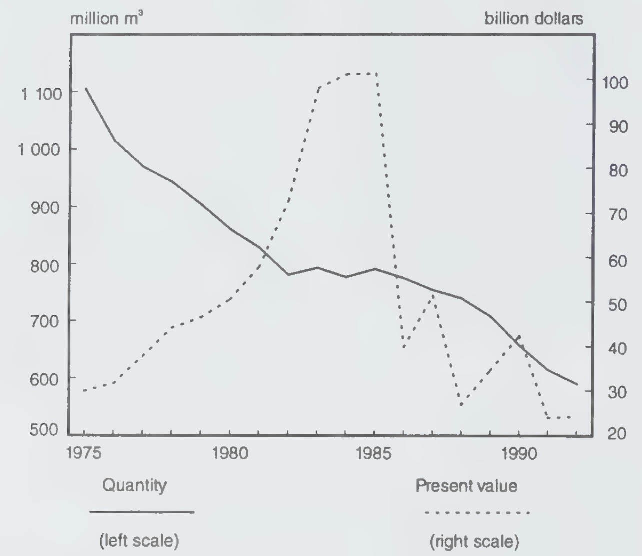
1. For a more complete discussion on mineral prices and their impact on the value of subsoil assets, see Born (1995).

2. In Canada, the term *established* reserves is used for oil, crude bitumen and natural gas reserves, *recoverable* reserves for coal and uranium reserves and *proven and probable* reserves for nickel. While these definitions reflect reporting conventions in Canada, they are considered to be similar.
3. For a more complete discussion of the quantity and value of Canada's coal reserves, see Born *et al.* (1995).
4. The price quoted here is per kilogram U (uranium).

1979. The value shows declines from 1979 to 1986, increases in the late 1980s followed by a strong decline in 1989 due to large deliveries of former U.S.S.R. nickel into the market and the effects of the recession.

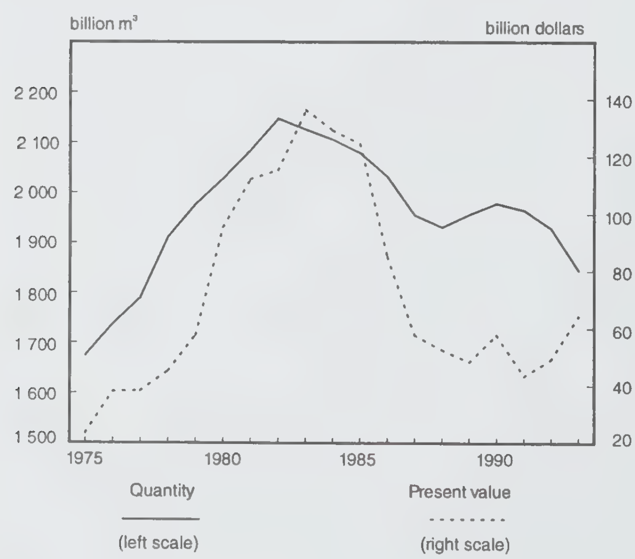
While monetary valuation of developed mineral reserves is necessary in order to calculate wealth, these values alone do not clearly indicate trends in the remaining reserves from which income is to be derived, nor do they show whether "resource rents" are being consumed or reinvested elsewhere in the economy. Physical accounting provides a measure of resource availability in the medium or long term depending on the reserve definition used. Monetary valuation is only one aspect of natural resource accounting, and it is just as useful to measure a resource in physical terms than in monetary ones. From a national accounts' perspective, a natural resource is as much an economic as a physical concept.

Figure 6.1
Quantity and Present Value of Established Oil Reserves, 1975-1992



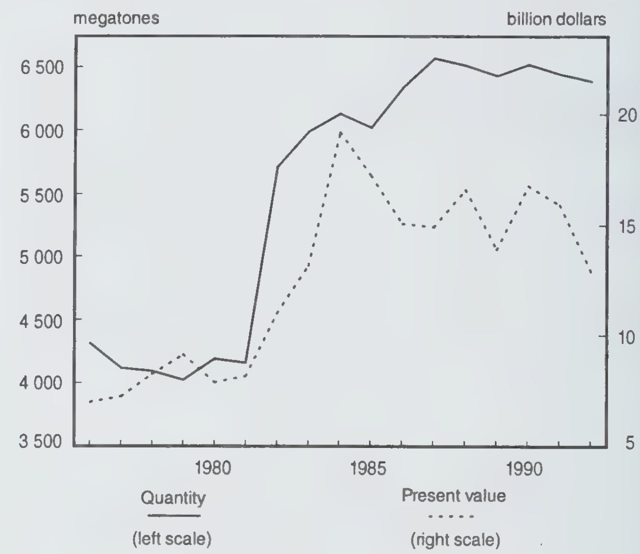
Source:
Statistics Canada, National Accounts and Environment Division.

Figure 6.2
Quantity and Present Value of Established Natural Gas Reserves, 1975-1992



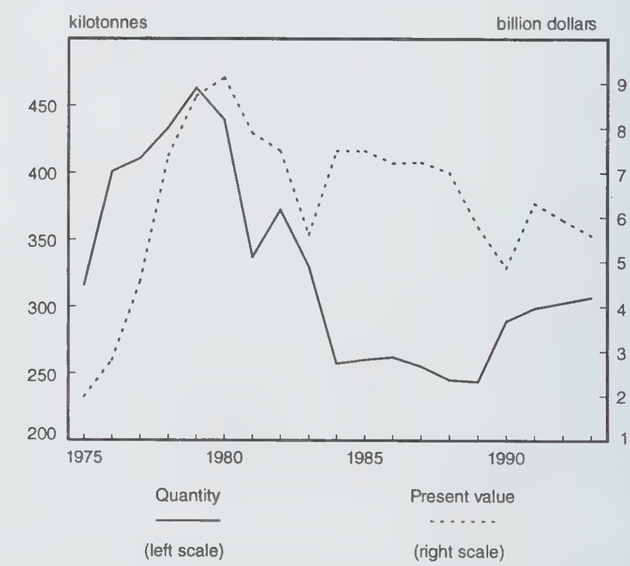
Source:
Statistics Canada, National Accounts and Environment Division.

Figure 6.3
Quantity and Present Value of Recoverable Coal Reserves, 1975-1992



Source:
Statistics Canada, National Accounts and Environment Division.

Figure 6.4
Quantity and Present Value of Recoverable Uranium Reserves,1975-1992



Source:
Statistics Canada, National Accounts and Environment Division.

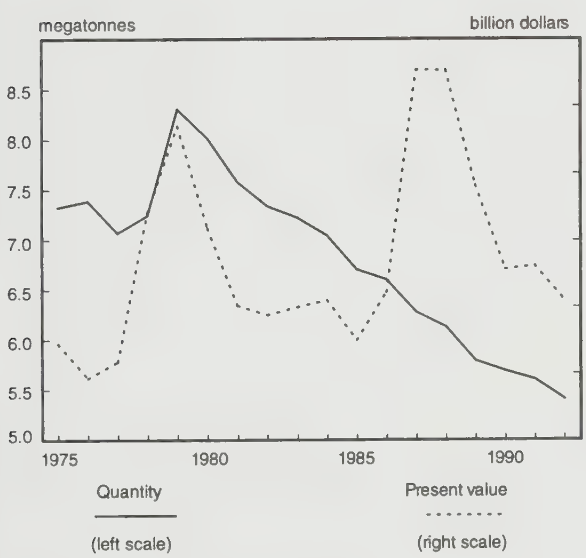
Text Box 6.1
Sustainability and Capital Maintenance

In order to make the concept of sustainability operational, it is usually reduced to that of capital maintenance as "a reasonable indicator of baseline sustainability" (Bartelmus, 1996). Several definitions of sustainability reflecting different approaches to capital maintenance have been proposed (Bartelmus, 1996; Daly, 1995; and Serageldin and Steer, 1994):

- *Weak sustainability* seeks to maintain income flows without regard to composition of capital (e.g. produced, natural, human and social). It assumes that produced and natural capital are substitutable and thus, that only their sum need remain intact.
- *Sensible sustainability* requires that, in addition to maintaining the total level of capital, its composition should be taken into account (i.e. ensuring that the levels of the different types of capital are maintained). Oil may be depleted if the receipts it yields are invested in other forms of capital. According to this definition, produced and natural capital are substitutable but also complementary.
- *Strong sustainability* requires the full preservation of the natural resource or at least that the different types of capital remain intact, that is, receipts from oil extraction should be invested in renewable types of energy. It assumes that produced and natural capital are complementary, which requires that each be maintained intact separately.

The focus of weak sustainability is income maintenance, by reinvesting returns in other production processes rather than looking for substitutes of the resource being depleted. The question is how much income derived from resource extraction should go to consumption, saving, or investment in other forms of capital (weak sustainability) or in substitutes for the resource (sensible sustainability). For natural assets that are non-renewable, such as subsoil assets, the criterion of strong sustainability must be relaxed. In its most extreme form, strong sustainability is not a viable approach, since the non-use of a nation's natural resource can be considered squandering part of a country's economic potential. In this paper, indicators reflecting both sensible and weak sustainability are examined.

Figure 6.5
Quantity and Present Value of Proven and Probable Nickel Reserves, 1975-1992



Source:
Statistics Canada, National Accounts and Environment Division.

Sustainable development and mineral resources

The most familiar definition of sustainable development is that of the Brundtland Commission: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." It follows that the national accounts should provide an indication of the extent to which a country meets the basic material needs of its inhabitants and will be able to do so in the future (Schrecker, 1995).

The *economic* approach to sustainable development is based on the principle of generating a maximum income flow while maintaining the stock of capital (Text Box 6.1). The controversy over the degree of substitution of produced capital for natural capital translates into a continuum of conditions for sustainable development, between what is known as *weak* and *strong* sustainability. However, it is this maintenance of capital or a nation's wealth, both produced and natural, that is at the heart of sustainable development, no matter how it is defined (Hamilton, 1994).

If it is accepted that rents from natural capital depletion (both renewable and non-renewable) should be shared with future generations, then sufficient assets should be maintained to ensure a non-decreasing flow of income or welfare (per capita). Total capital stock, in monetary terms, may be preserved if revenues from the resources being depleted are invested in other forms of productive capital. However,

it is difficult to identify the types of capital to be maintained (e.g. produced, natural, intangible or human capital) and to value some of these assets (Munasinghe, 1993; Born, 1992).

Sustainable development requires that consumption by present generations should not be at the expense of future generations. For subsoil assets, this imposes two conditions. First, investments should be made in alternative wealth-generating assets as a substitute for the depleting mineral asset. Second, the environmental damage caused by mining and smelting and by consumption should be minimized (Auty and Warhurst, 1993). For subsoil assets, especially fossil fuels, the limited carrying capacity of the environment implies that the second constraint is more important than the first one (the depletion of the resources).

The sustainable development of subsoil assets raises a number of questions such as the valuation of annual depletion, the substitutability of produced capital for depleted mineral resources and the mechanism for transferring the "capital value" of the depletion to future generations. Some environmentalists suggest that sustainable development requires limiting the rate of mineral extraction to the rate at which their renewable substitutes are developed. Since the exact physical volume of mineral stocks can vary from year to year with discoveries, technological change, depletion and resource evaluation, we do not know the optimal depletion path for these resources (Mikesell, 1994). The problem of sharing mineral resources with future generations is estimating when supplies will be exhausted at current rates of depletion.

Physical stocks of minerals are depleted by each generation even though additional reserves are added to the "recoverable" stock. However, extraction does not represent a loss of "capital value" if an equivalent value of additional reserves is discovered. It would suffice to maintain the capital value of mineral reserves for future generations to be assured an income equal to that earned from the reserves by the present generation.

However, this assumes that produced capital financed by the rent from mineral depletion is a substitute for the depleted mineral. It also raises the issue whether sustainable development requires a constant stock of both produced capital and natural capital or just total capital stock. If there is a high degree of substitutability between produced capital and natural capital such as minerals, the reinvestment of the rent from the extraction of subsoil assets should prevent future economic output from being constrained by depletion of minerals (Mikesell, 1994). The assumption of strong sustainability, on the other hand, implies the need to maintain both produced and natural capital.

Wealth accounts are one measure of weak sustainable development, and could be complemented by others. Such accounts would help to answer the question of how human activities impact the potential of natural resources to generate income in the future (Schrecker, 1995).

Table 6.3 presents wealth accounts and wealth per capita for Canada including preliminary estimates of subsoil assets. Increases in the value of the latter are mainly attributable to the revaluation of resource prices and costs over the period, the value of reserve additions being less than that of depletion. The physical accounts, however, show a different picture. Except for uranium, all recoverable reserves are being depleted and not being replaced (Table 6.4). At this time, we cannot determine whether the owners of subsoil assets, mainly provincial and federal governments, employ the rent derived from their extraction to produce other assets. However, Canada's wealth and wealth per capita are being maintained and are increasing over time.

Government revenues from the extraction of natural resources represented approximately 3.5% to 4.0% of total provincial and territorial government revenues between 1990 and 1995. For a province such as Alberta which produces about 80% of Canada's oil and natural gas, the percentage increases to about 20%. Since most natural resources in Canada are owned by provincial and federal governments, it is likely that most of the returns from the extraction/harvesting of these resources are invested in health care or education and therefore human capital. In Alberta, 30% of oil and natural gas revenues were put into its Heritage Savings Trust Fund for a number of years and reinvest-

Table 6.3
Expanded Wealth Accounts, 1992[1]

	Produced assets	Non-produced assets		Wealth per capita	
		Land[3]	Subsoil assets	Excluding subsoil assets	Including subsoil assets
	billion dollars			dollars per capita	
Opening stock (December, 1991)	**1 897.7**	**559.9**	**118.7**	**86 788**	**90 979**
Depletion of non-produced assets	...	..	6.4	...	...
Use of produced assets	..	...	...	...	...
Other volume changes[2]	..	..	5.6	...	...
Revaluation due to market price changes	..	..	-	...	...
Closing stock (December, 1992)	**1 940.1**	**587.5**	**117.9**	**87 942**	**92 044**

Notes:
1. Includes the value of Canada's oil, natural gas, crude bitumen, coal, uranium, and nickel reserves. Excluded are the value of iron, potash, gold, silver, copper, zinc, lead, and molybdenum.The results presented here are preliminary.
2. Includes changes in technological progress, prices, costs and estimation methods.
3. The value of land includes residential, non-residential and agricultural land.

Source:
Statistics Canada, National Accounts and Environment Division.

Table 6.4
Physical Accounts of Subsoil Assets, 1992

	Crude oil	Natural gas	Crude bitumen	Coal	Uranium	Nickel
	million m^3	billion m^3	million m^3	megatonnes	kilotonnes	kilotonnes
Opening stock (December, 1991)	**614.1**	**1 965.3**	**501.7**	**6 434.2**	**305.0**	**5 691**
Depletion of sub-soil assets	69.8	125.7	23.8	79.0	9.1	231
Other volume changes[1]	44.4	89.7	4.3	23.0	13.1	145
Closing stock (December, 1992)	**589.8**	**1 929.5**	**482.2**	**6 378.3**	**309.0**	**5 605**

Notes:
Figures may not add due to rounding.
1. Includes changes in technological progress, prices, costs and estimation methods.
Source:
Statistics Canada, National Accounts and Environment Division.

ed in other forms of capital. In Alberta's case, some of the resource rents were converted to other forms of assets through investments in public infrastructure, public enterprises and human capital (health and education expenditures). However, in recent times, no revenues have been placed in the fund. Calculations by Smith (1992) suggest that from 1963 to 1988, the Alberta government was consuming revenues from oil and gas extraction at a rate that may have resulted in a decrease in the wealth over time.

Conclusion

If sustainability is going to be more than a slogan, it requires a definition, some quantitative objectives and some indicators for measuring progress or regression. Sustainable development is a macroeconomic issue since it concerns all resources: produced, natural and human capital. The aim is to sustain welfare, i.e. the consumption of economic and environmental goods and services, for present and future generations. A more accurate picture of the capital base on which future income and consumption depend, requires the inclusion of natural capital in wealth accounts.

It is the availability of natural capital and the absorptive capacity of the environment that will pose limits to sustainable economic growth. Developing alternative growth indicators and including measures of natural capital and its depletion in economic growth models could provide tools to determine what is sustainable economic growth (Bartelmus, 1992). The definition of sustainability in terms of capital maintenance requires that the owners of natural capital invest the rent in the production of other assets.

Does the concept of capital maintenance refer to the "capital value" of mineral resources or to the physical volume of natural resource stocks? As suggested by Peskin (1996), the distinction is important in the case of natural capital, since there may be little association between an asset's physical condition and its value. As shown in this paper, there is a need for both physical and monetary accounts. Yet if one talks about economic sustainability, it is economic value that is used to measure total national wealth (produced, human and natural capital).

If the measure of national wealth is expanded to include the value of subsoil assets and timber resources, then total wealth per capita may become a useful indicator of sustainability. If wealth per capita does not decline, then (economic) development is considered to be sustainable. Whether or not GDP or an adjusted "green" GDP per capita adequately measure short-run economic performance, wealth per capita does give a picture of how wealth creation and population growth influences future income per capita.[1] This is, for Statistics Canada, an area of future work in natural resource and environmental accounting.

References

Adelman, M.A., Harindar De Silva and Michael F. Koehn, 1991, "User Cost in Oil Production," *Resources and Energy*, Volume 13, p. 217-240.

Auty, Richard, and Alyson Warhurst, 1993, "Sustainable Development in Mineral Exporting Economies," *Resources Policy*, March, p. 14-29.

Bartelmus, Peter, 1992, "Accounting for Sustainable Growth and Development," *Structural Change and Economic Dynamics*, Volume 3, No. 2, p. 241-260.

Born, Alice, 1992, *Development of Natural Resource Accounts: Physical and Monetary Accounts for Crude Oil and Natural Gas Reserves in Alberta, Canada*, National Accounts and Environment Division, Discussion Paper No. 11, Statistics Canada, Ottawa.

Born, Alice, Marcia Santiago and Véronique Dumas, 1995, "Quantity and Value of Canada's Coal Reserves", in *Environmental Perspectives 2: Studies and Statistics*, Statistics Canada, Catalogue No. 11-528E, Ottawa, p. 55-64.

Born, Alice, 1995, *Valuation of Canada's Mineral Resources: A Discussion of Conceptual Issues*,

1. Hamilton (1994) describes the policy implications of the "greening" of national accounts and of the inclusion of natural capital among the assets. He shows how the growth in wealth can be separated from the growth in population.

National Accounts and Environment Division, Discussion Paper No. 21, Statistics Canada, Ottawa.

Daly, H., 1995, "On Wilfred Beckerman's Critique of Sustainable Development," *Environmental Values*, Volume 4, p. 49-55.

Hamilton, Kirk, 1994, "Green Adjustments to GDP," *Resources Policy*, Volume 20, No. 3, p. 155-168.

Mikesell, Raymond, 1994, "Sustainable Development and Mineral Resources," *Resources Policy*, Volume 20, No. 2, p. 83-86.

Mungasinghe, M., 1993, *Environmental Economics and Sustainable Development,* World Bank Environment Paper No. 3, Washington, D.C.

National Energy Board, 1994, *Canadian Energy: Supply and Demand 1993-2010*, Catalogue No. NE23-15/1994E, Calgary.

Natural Resources Canada, 1993a, *Statistical Review of Coal in Canada 1993*, Mining Sector, Ottawa.

_____, 1993b, *Uranium in Canada: Assessment of Supply and Requirements*, Uranium Resource Appraisal Group, Uranium Division, Ottawa.

Peskin, H. 1996, *Alternative Resource and Environmental Accounting Concepts and Their Contribution to Policy*, Paper presented at the Special Conference on Integrated Environmental and Economic Accounting, International Association for Research in Income and Wealth, Tokyo, Japan, March 5-8, 1996.

Schrecker, Ted, 1995, "Commonplaces and Heresies about the Human-Ecosystem Interface," in Hodge, Tony *et al.* (eds.), *Pathways to Sustainability: Assessing Our Progress*, National Round Table on the Environment and Economy, Ottawa, p. 80-84.

Serageldin, I., and A. Steer, 1994, "Epilogue: Expanding the Capital Stock," in Serageldin, Ismail, and Andrew Steer (eds.), *Making Development Sustainable: From Concepts to Action*, Environmentally Sustainable Development Occasional Paper Series No. 2, The World Bank, Washington, D.C., p. 30-32.

Smith, Philip, 1994, "The Canadian National Accounts Environmental Component: A Status Report", in *National Income and Expenditure Accounts, Annual Estimates, 1982-1993*, Statistics Canada, Catalogue No. 13-201, Ottawa.

Smith, Roger S., 1992, "Income Growth, Government Spending and Wasting Assets - Alberta's Oil and Gas," *Canadian Public Policy*, Volume 18, No. 4, p. 387-412.

United Nations, Commission of the European Communities – Eurostat, International Monetary Fund, Organization for Economic Co-operation and World Bank, 1993, *System of National Accounts 1993*, STAT Series F/2, Revision 4, New York.

United Nations, 1993, *Integrated Environmental and Economic Accounting*, Series F, No. 61, New York.

United States Bureau of Economic Analysis, April 1994, *Accounting for Mineral Resources: Issues and BEA's Initial Estimates*, Survey of Current Business, Washington, D.C.

Victor, Peter, 1990, "Indicators of Sustainable Development: Some Lessons from Capital Theory," in Victor, P., *et al.* (eds.), *Indicators of Ecologically Sustainable Development: Delineation Studies in Economic, Ecological and Decision Theory*, Ottawa.

World Bank, 1995, *Monitoring Environmental Progress: A Report on Work in Progress*, Washington, D.C.

7 Land Statistics for Canada

by Michael Bordt, Doug Trant, Giuseppe Filoso, Hélène Trépanier and Jeff Fritzsche, National Accounts and Environment Division; Ken Korporal, Agriculture Division

Introduction

The objective of this chapter is to provide an assessment of the current status of land statistics in Canada. Broadly defined, land statistics concern land cover, use, potential and value. There is no harmonized source for this information for all of Canada. This paper describes the existing sources of land information and proposes a methodology for estimating several national-level land statistics which are currently not regularly reported.

The need for land statistics

Land statistics have been of importance mainly to track ownership, local land-use plans and resource potential. National statistics on agricultural land use have been collected since the first *Census of Agriculture* in 1881. The advent of land-use planning brought about the need for additional information to take into account as many factors as possible in order to harmonize local land uses and thereby avoid future conflicts.

More recent environmental and resource concerns require more extensive and detailed information. The natural landscape is constantly being modified either intentionally to suit human purposes or as a by-product of our activities. As the nature of the land changes, so does its ability to provide the necessary functions for humans and natural ecosystems alike.

Except for lands used for agriculture and forestry there are no detailed national-level data on land use. *The State of Canada's Environment* (Government of Canada, 1992; p. 5-17) well states the current situation:

> At every level – national, provincial, regional and local – our knowledge of the land base itself is inadequate. In many instances, basic resource inventories, from which land-use interpretations can be made, remain incomplete or are outdated. Following the termination of the Canada Land Use Monitoring Program of Environment Canada, in place from 1978 to 1988, there is a need for national data indicating how much land is used and how land use changes from year to year. Nationally, Canada has not determined how much land will be needed for different purposes in the future, nor is there agreement on how to establish the true value of land uses, to compare with those established by the market.

Land issues

The Federal/Provincial Committee on Land Use (1996) sponsored a forum in 1995 to discuss common issues in land use. The issues were classified according to four key land-use categories: agriculture, forestry, shore zone/coastal zone, and urban. The detailed issues that were discussed are listed below.

Agriculture:

- degradation of agri-ecological resources through agricultural practices;
- on and off-farm effects;
- lack of an agricultural land policy;
- loss of the agricultural land base;
- competing uses on rural lands.

Forestry:

- multiple-use conflicts;
- impact of forest management practices on production and the environment;
- inclusion of aboriginal needs and interests in forest management.

Shore zone/coastal zone:

- impact of land sources of pollution;
- competing use of shore areas (such as aquaculture and recreation);
- restriction of public access to the shore.

Urban:

- planning and financing of hard services and infrastructure;
- protection of water supplies;
- impact of urban related development in rural areas (such as urban sprawl and ribbon development).

Issues common to all categories:

- present governance systems unable to identify and solve problems (or take advantage of opportunities);
- lack of current data and measurable indicators of land-use patterns and change;
- inadequate valuation of common resources; and
- lack of integrated planning and communication.

Besides providing a useful overview of common land-use issues, the above list emphasizes the importance of applying information, common indicators and approaches to valuation. The Federal/Provincial Committee also highlighted

the shore/coastal zone issues which are generally not considered in land-use discussions.

Land-related policies range from general statements of intent to subsidies for specific activities. One of the confounding factors in land policy, and therefore supporting statistics and information, is that often three or more jurisdictions (federal, provincial/regional, municipal, private, non-governmental) may influence the use of a given tract of land.

Jurisdiction: In general, the Parliament of Canada controls the lands that are owned by the Federal Government including national parks, aboriginal reserves, airports, defence establishments, harbour sites, government buildings, Sable Island, and 99% of the land in the Yukon and Northwest Territories. Federal agricultural, transportation, defence, housing and energy policies also directly influence the use of land in many areas. The main policies cited in *Land Use in Canada* (Environment Canada, 1980) are listed below:

- **Fiscal Policies:** federal monetary, taxation, and trade and tariff policies;
- **Sectoral Support Programs:** income support and credit-assistance programs in various economic sectors, particularly agriculture and industry;
- **Regional Development Programs:** development programs to stimulate economic growth in less-developed regions;
- **Federal Lands and their Management:** public lands under the administration of the Federal Government, mostly (97%) in the Yukon and Northwest Territories (the remaining 3% is used to support the programs of federal agencies);
- **Regulatory Powers in Transportation:** Regulatory powers over transportation rates affect the viability of resource industries (agriculture, forestry, and mining) and related secondary industries; and
- **Research and Information Activities:** programs that include land inventories; soil, geological and wildlife surveys; National Research Council activities; the Canada Mortgage and Housing Corporation.

Land-use planning on privately-owned land is a municipal or regional function supervised by the provinces. Land taxes are levied by most municipalities (Environment Canada, 1980).

Many policy areas transcend jurisdictions. Issues such as sustainable development, biodiversity, resource use, financial policy and land-use planning often involve many levels of government.

Sustainable development: Many approaches to understanding the sustainability of our actions relate to the carrying capacity of the environment. Wackernagel (1993) calculates the "ecological footprint" of various activities by estimating the area of land required to support one person or one city. The broader issues require information on land use and land-use changes, land quality and land cover. With better land statistics critical areas could be more easily identified and priorities could be more easily set.

Canada's Green Plan (Government of Canada, 1990) cited land issues in many of the priority objectives for Canadians including:

- clean air, water and land;
- sustainable use of renewable resources (including sustainable agriculture and sustainable forestry);
- preserving the integrity of our North; and
- protection of our special spaces and species (i.e. protected areas and biodiversity).

The more recent federal government statement of its sustainability objectives (Government of Canada, 1995) urged federal departments to adopt "best practices" for the management of federal lands including:

> The identification, classification and assessment of sites of concern on departmental lands should be undertaken using the CCME (Canadian Council of Ministers of the Environment) National Classification System or a similar tool; and the management of the risk to human health and the environment [on federal lands] should include risk assessment and techniques for containment, mitigation and remediation.

Biodiversity: Information on the extent and quality of special habitats is an essential component to understanding the current and potential state of Canada's wildlife. One direction of Statistics Canada's Wildlife Accounting Project is to account for habitats of species that are difficult to enumerate (migratory birds, small mammals and insects).

Statutory protection of a unique habitat is often seen as an adequate approach to ensuring the protection of important species. However, risks imposed by activities on land surrounding the protected areas should also be considered. Trant (1993) provides a detailed assessment of agricultural activities for the surroundings of Riding Mountain National Park in Manitoba.

Resource use: Statistics on forests and agricultural land are relatively well developed since they feed into important economic sectors. Canada's Forest Inventory (Natural Resources Canada, Canadian Forest Service, 1995), and the Agricultural Land Potential Database (Agriculture Canada, 1991) are updated frequently and workable classification systems are in effect. Statistics on the land aspects of other resource uses such as mining, water use and wildlife are lacking.

Ownership and taxation: The extent of land and its ownership has always been important for taxation purposes. Some of the best information on land use exists in municipal registry offices. New needs for land statistics are suggested by new policies on liability of lenders for environmental clean up. Insurers are also concerned about environmental

risk assessment before lending money for real estate purchases.

Economic policy: Most economic policies relating to land include the establishment of agricultural subsidies, definition of transportation corridors, initiation of major infrastructure projects and delineation of settlement areas. One indicator of Canada's national wealth is Canada's National Balance Sheet (Statistics Canada, 1995), which includes annual estimated values of agricultural, residential and commercial land.

Land-use planning: This type of planning is normally conducted at the municipal or regional level under guidelines from the provincial government. The assembly of land-use and zoning data is often the first stage of planning at this level.

Research: Although research and analysis often feeds into policy, their overall objective is more often to contribute to the general scientific understanding of environmental processes and systems.

The analysis of land-use change and its impacts has typically been conducted on a local scale. Beginning in the 1950s, the Geographical Branch of the Department of Energy, Mines and Resources Canada and, afterwards, the Lands Directorate of Environment Canada issued a series of Geographical Papers, many of which focused on land and water use.[1]

One of the major research issues today is the understanding of land surface ecosystem processes and global change. The BOREAS[2] project investigated these relationships through extensive monitoring of two 20 km^2 study areas in the boreal zone of Manitoba and Saskatchewan. The main objective of the work was to collect data that would provide insight into the relationship between land processes (for example, ecosystems, climate and geology) and the sustainable use of resources. The general conclusion after two years of detailed research was that the detailed information collected for two small areas as part of this study cannot be readily applied to the rest of the country. This detailed information, which is required to understand the complex interactions, is available for a few isolated sites (Post-BOREAS Task Group, 1995).

Land Information is internationally regarded as a key to understanding and predicting global change. Turner, Moss and Skole (1993) write:

> Gaining a better understanding of the ways that land cover and land-use practices are evolving is a priority concern of the global change research community. The characteristics of land cover have important impacts on climate, biogeochemistry, hydrology, and the diversity and abundance of terrestrial species. Hence, being able to project future states of land cover is a requirement for making numerical predictions about other global changes.

1. Examples include Vancouver, Victoria, Ottawa, Georgian Bay (Energy, Mines and Resources Canada, 1968, 1969a, 1969b, 1970); and the Gulf of St. Lawrence, Prince Edward Island and the Musquodoboit Valley in Nova Scotia (Environment Canada, 1973a, 1973b, 1974a, 1974b).
2. The Boreal Ecosystem-Atmosphere Study (BOREAS) is jointly managed by NASA in the United States and Natural Resources Canada.

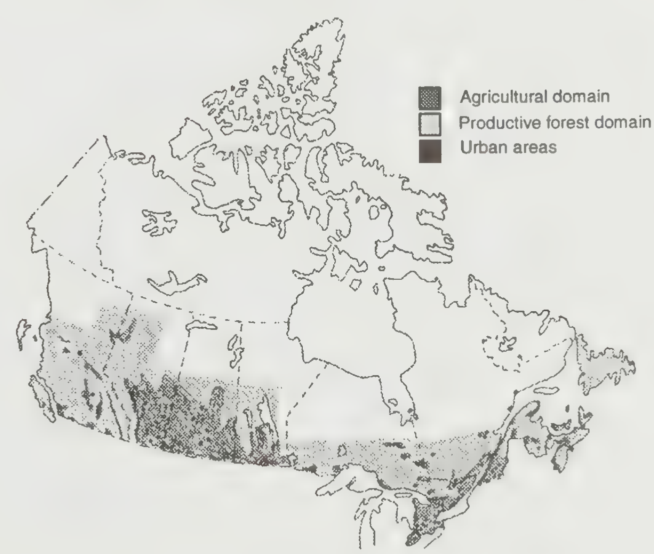
Despite general agreement on the importance of land information, Canada is losing land information rather than generating it. Several key historical datasets, the Canada Land Inventory (CLI) and Canada Land Use Monitoring Program (CLUMP) have been archived and are no longer available to support policy decisions and research.

The development of land statistics

Canada Land Inventory: Until the 1960s, detailed national information on land cover and land use was available mainly for agricultural and forested areas. The CLI was initiated in 1963 under federal-provincial agreement. The program coordinated the mapping of 2.5 million km^2 of Canada's settled lands. By interpreting local maps and air photos, an extensive database of land capability was built up at a 1 : 50 000 scale. The resulting database provided an assessment of the potential of the land for agriculture, forestry, recreation, and wildlife (waterfowl and ungulates). Current land use, generally for 1967, was also recorded. These data have been widely used for land-use planning at the regional level and were housed in the Canada Geographic Information System (CGIS), one of the world's first GISs, developed specifically for this purpose (Environment Canada, 1981).

In 1974, an **Interdepartmental Task Force on Land Use** was established by the federal government. This group concluded that the main role of the federal government was to establish guidelines for its own activities as they affect the use of land (Environment Canada, 1980). This led to the development of the Federal Policy on Land Use in 1980.

Map 7.1
The CLUMP Framework



Canada Land Use Monitoring Program (1980-85): The Canada Land Use Monitoring Program (CLUMP, Map 7.1), which was intended to maintain an updated national database of land-use/land-cover data, existed for only a few years in the early 1980s. During this period, Environment Canada's Lands Directorate generated some of the most detailed and informative analyses of land use and land-use changes ever published in Canada. This includes a series on specific land-use issues (such as agricultural land value, land used for mining) and assessments of land-use programs in each province (for example, Environment Canada, 1977 and Environment Canada, 1982). One perspective on land use available from this series is presented in Table 7.1.

Another major output from CLUMP was a highly detailed classification of land use and a separate one for land cover. In many classification systems, these are combined to form a hybrid. Separating land use from land cover allows the distinction between ecological state of the land and the human uses.

In 1981, Statistics Canada (1981) issued a report which summarized the current status of land statistics in Canada. The report detailed sources (and potential sources) of land information from Statistics Canada, other federal departments, provincial governments and municipalities and proposed the CLUMP framework as a working model.

Federal Policy on Land Use: In 1980, a statement was issued by Environment Canada which defined *Federal Policy on Land Use* (Government of Canada, 1981). This policy was directed at minimizing environmental impacts of decisions related to federally managed lands. The document also proposed that the federal government provide a coordinated program of surveys and socio-economic, scientific and technical research on land capability, characteristics, tenure and use. It further stated that:

> Surveys and research in the fields of:
>
> - geological surveys
> - topographical mapping
> - soils
> - ecological mapping
> - social, economic and environmental aspects of land use
> - identification of critical lands
> - land-use monitoring
> - forest inventories
> - water surveys
> - collection of socio-economic data relating to land use
>
> are key elements in the formulation of sound land management strategies by all who influence the use of land.

Although CLUMP was designed to achieve these objectives, the program ended in 1988 with the dissolution of Environment Canada's Lands Directorate. Some of the Directorate's responsibilities, staff and data holdings became part of Environment Canada's State of the Environment Reporting Branch where the work initiated on ecological land classification continued.

Table 7.1
National Land Use, 1976-1979

	Area	Proportion of area
	thousand ha	percent
Land resource base		
Agricultural areas	73 000	7.3
Forestry		
Productive	207 900	20.8
Unproductive	94 800	9.5
Unclassified	39 000	3.9
Wildland	503 700	50.5
Urban		
Built up	1 569	0.2
Roads, parks, greenbelts	1 831	0.2
Fresh water areas	75 516	7.6
Canada total	**997 316**	**100.0**
	thousand ha	
Special land and water uses[1]		
Transport		
Railways	506	
Highways, roads, streets	2 590	
Airports	613	
Marine transport	44	
Mining		
Claims, grants, leases	39 600	
Land disturbed and alienated	285	
Energy		
Petroleum leases (onshore)	65 600	
Petroleum pipelines	60	
Natural gas pipelines	80	
Electrical transmission lines	340	
Hydroelectric headpond storage	1 620	
Protected lands		
Parks and park reserves	39 590	
Wildlife protection areas	56 879	
Indian reserves	2 927	
Military bases and reserves		
Owned	597	
Leased	1 206	

Note:
1. These special land use categories overlap and should not be summed.
Source:
Environment Canada, 1982.

Recent Canadian initiatives

Natural Resources Canada – Canada's Forest Inventory: The forest inventory is conducted on an on-going basis through cooperation with provincial governments. The coverage of the inventory and its match with actual land-cover information is shown in Map 7.2.[1] The inventory includes estimates of the area of several different land and forest

1. Maps 7.2 through 7.8 are found at the end of the chapter.

conditions that occur in each of about 58 thousand map cells (Gray and Neitman, 1989). The national inventory is taken from provincial and territorial forest inventories. For Canada's timber-productive, non-reserved forest land (245 million hectares or 27% of the total land area), a significant amount of detail is available on ownership and use (Canadian Council of Forest Ministers, 1993). Table 7.2 provides a provincial perspective on land use based on these statistics.

Agriculture Canada – National Soil Database (NSDB): The National Soil Database covers soil, landscape and climatic data collected over the past 80 years. The most detail is available for Canada's agricultural land but non-agricultural areas are covered as well. Its major components include:

- the Land Potential Database (LPDB), which covers all of Canada at a scale of 1 : 5 million (Map 7.3 shows land use/land cover based on the LPDB);
- Soil Landscapes of Canada, which includes more detail on major soil and landscape attributes at a scale of 1 : 1 million;
- National Ecological Framework (1 : 2 million scale);
- Agroecological Resource Areas, covers the three Prairie Provinces at a scale of 1 : 2 million and includes details on climate, economy, crop, soil and landscape attributes; and
- Detailed Soil Surveys, conducted at varying scales.

Environment Canada/Agriculture and Agri-Food Canada – National Ecological Framework: This framework is based on a common system of classifying and mapping terrestrial ecosystems. It was developed in the 1970s and 1980s by professionals from government, non-government organizations, universities, and industry through the Canadian Committee on Ecological Land Classification. The framework describes ecologically distinct areas of the earth's surface at different levels of generalization, ranging from the broad scale ecozones to more detailed ecodistricts.

The framework serves as a common ground for interpreting existing and new information about ecosystems independently of jurisdictional boundaries. The framework also contains marine and international components.

The terrestrial component of the National Ecological Framework (ecozones, ecoregions and ecodistricts) has been recently revised in cooperation with federal and provincial agencies and other stakeholders. The revision was conducted to enhance the capability of both government and non-government organizations to assess and report on environmental conditions and the sustainability of ecosystems in Canada. This has resulted in refinement to boundaries of the original Ecozone map published in the first State of the Environment Report for Canada (Environment Canada, 1986; Wiken, 1986). Map 7.4 and Table 7.3 show the revised Ecozone map for Canada (Ecostratification Working Group, 1995). Major features of the terrestrial component include:

- a map of ecozones and ecoregions of Canada, at a scale of 1 : 7.5 million;
- a map of ecodistricts on a separate series of six regional maps at a scale of 1 : 2 million (Atlantic Provinces, Quebec, Ontario, Prairie Provinces, British Columbia, and the Yukon and Northwest Territories);
- the National Ecological Framework Database, which includes information on biophysical attributes for ecodistricts at a scale of 1 : 2 million; and
- a national report that includes narrative descriptions of ecozones and ecoregions.

Federal/Provincial Committee on Land Use: This group has been active since 1974 in coordinating federal, provincial and territorial government cooperation in inter-jurisdictional land-use issues. Recent activities have focused on information exchange and issue identification. Major questions addressed at a recent forum include:

- What are the major land-use issues facing the country over the next decade?
- What are the broad options for resolving these issues?
- What roles does and should land-use planning play in the implementation of sustainable development?

Natural Resources Canada – National Atlas of Canada: The National Atlas has been presenting invaluable information on Canada's land since 1906 (Energy, Mines and Resources Canada, 1993). Several unique perspectives on land have been developed within this program. One example is the land-cover map synthesized from remote sensing data collected over a three-year period. Table 7.4 is derived from this map. Map 7.5 is a further generalization of the original vegetation cover map which contained 12 land-cover classes:

- forest land
  - continuous forest
    - coniferous forest
    - broadleaf forest
    - mixed forest
  - transitional forest
- tundra
- sparsely vegetated/barren land
- agricultural land
  - cropland
  - rangeland and pasture
- nonvegetated land
  - perennial snow or ice
  - built-up area
- water/sea ice
  - open water
  - sea ice.

Table 7.2

Land Classification by Province and Territory, 1991

Land class	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	thousand hectares												
A. Forest land													
Reserved	12 054	93	-	97	-	377	1 699	261	678	4 358	3 268	118	1 105
Timber-productive	8 661	59	-	96	-	345	1 485	245	647	2 443	2 685	73	583
Timber-unproductive	2 877	34	-	1	-	32	214	16	31	1 621	567	45	316
Unspecified timber-productivity	516	-	-	-	-	-	-	-	-	294	16	-	206
Non-reserved	401 415	22 431	294	3 736	6 106	82 054	55 981	26 016	28 011	31 734	57 289	27 431	60 332
Timber-productive	234 534	11 212	278	3 671	5 954	54 390	40 674	14 994	11 986	21 194	49 046	7 397	13 738
Timber-unproductive	164 049	11 219	16	65	152	27 664	15 307	11 022	16 007	10 347	8 243	19 976	44 031
Unspecified timber-productivity	2 832	-	-	-	-	-	-	-	18	193	-	58	2 563
Unclassified	2 706	-	-	90	-	54	315	-	117	2 122	8	-	-
Timber-productive	2 175	-	-	-	-	54	45	-	-	2 068	8	-	-
Timber-unproductive	531	-	-	90	-		270	-	117	54	-	-	-
Unspecified timber-productivity	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	416 175	22 524	294	3 923	6 106	82 485	57 995	26 277	28 806	38 214	60 565	27 549	61 437
Timber-productive	245 370	11 271	278	3 767	5 954	54 789	42 204	15 239	12 633	25 705	51 739	7 470	14 321
Timber-unproductive	167 457	11 253	16	156	152	27 696	15 791	11 038	16 155	12 022	8 810	20 021	44 347
Unspecified timber-productivity	3 348	-	-	-	-	-	-	-	18	487	16	58	2 769
B. Nonforest land	505 368	14 645	272	1 361	1 103	53 194	31 124	28 559	28 264	26 225	32 408	20 348	267 865
Agricultural	67 753	47	259	397	376	3 430	5 451	7 725	26 865	20 811	2 392	-	-
Other	437 615	14 598	13	964	727	49 764	25 673	20 834	1 399	5 414	30 016	20 348	267 865
C. Total land	921 543	37 169	566	5 284	7 209	135 679	89 119	54 836	57 070	64 439	92 973	47 897	329 302
D. Fresh water	75 518	3 403	--	265	135	18 389	17 739	10 159	8 163	1 680	1 807	448	13 330
E. Total area	**997 061**	**40 572**	**566**	**5 549**	**7 344**	**154 068**	**106 858**	**64 995**	**65 233**	**66 119**	**94 780**	**48 345**	**342 632**

Land class	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	percent of total area												
A. Forest land													
Reserved	1.2	0.2	-	1.7	-	0.2	1.6	0.4	1.0	6.6	3.4	0.2	0.3
Timber-productive	0.9	0.1	-	1.7	-	0.2	1.4	0.4	1.0	3.7	2.8	0.2	0.2
Timber-unproductive	0.3	0.1	-	0.0	-	--	0.2	--	--	2.5	0.6	0.1	0.1
Unspecified timber-productivity	0.1	-	-	-	-	-	-	-	-	0.4	--	-	0.1
Non-reserved	40.3	55.3	51.9	67.3	83.1	53.3	52.4	40.0	42.9	48.0	60.4	56.7	17.6
Timber-productive	23.5	27.6	49.1	66.2	81.1	35.3	38.1	23.1	18.4	32.1	51.7	15.3	4.0
Timber-unproductive	16.5	27.7	2.8	1.2	2.1	18.0	14.3	17.0	24.5	15.6	8.7	41.3	12.9
Unspecified timber-productivity	0.3	-	-	-	-	-	-	-	--	0.3	-	0.1	0.7
Unclassified	0.3	-	-	1.6	-	--	0.3	-	0.2	3.2	--	-	-
Timber-productive	0.2	-	-	-	-	--	--	-	-	3.1	--	-	-
Timber-unproductive	0.1	-	-	1.6	-	-	0.3	-	0.2	0.1	-	-	-
Unspecified timber-productivity	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	41.7	55.5	51.9	70.7	83.1	53.5	54.3	40.4	44.2	57.8	63.9	57.0	17.9
Timber-productive	24.6	27.8	49.1	67.9	81.1	35.6	39.5	23.4	19.4	38.9	54.6	15.5	4.2
Timber-unproductive	16.8	27.7	2.8	2.8	2.1	18.0	14.8	17.0	24.8	18.2	9.3	41.4	12.9
Unspecified timber-productivity	0.3	-	-	-	-	-	-	-	--	0.7	0.0	0.1	0.8
B. Nonforest land	50.7	36.1	48.1	24.5	15.0	34.5	29.1	43.9	43.3	39.7	34.2	42.1	78.2
Agricultural	6.8	0.1	45.8	7.2	5.1	2.2	5.1	11.9	41.2	31.5	2.5	-	-
Other	43.9	36.0	2.3	17.4	9.9	32.3	24.0	32.1	2.1	8.2	31.7	42.1	78.2
C. Total land	92.4	91.6	100.0	95.2	98.2	88.1	83.4	84.4	87.5	97.5	98.1	99.1	96.1
D. Fresh water	7.6	8.4	-	4.8	1.8	11.9	16.6	15.6	12.5	2.5	1.9	0.9	3.9
E. Total area	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Note:
Figures may not add due to rounding.
Source:
Canadian Council of Forest Ministers, 1994.

Table 7.3

Ecozone Area by Province and Territory, 1991

Ecozone	Canada	Nfld.	P.E.I	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	thousand hectares												
Atlantic Maritime	20 375	-	706	6 918	9 156	3 595	-	-	-	-	-	-	-
Mixed Wood Plains	19 443	-	-	-	-	7 093	12 350	-	-	-	-	-	-
Boreal Shield	194 637	14 761	-	-	-	72 853	69 659	27 680	9 682	-	-	-	-
Prairies	47 811	-	-	-	-	-	-	6 780	26 140	14 891	-	-	-
Boreal Plains	73 780	-	-	-	-	-	-	8 679	18 995	32 653	10 365	2 923	164
Montaine Cordillera	49 211	-	-	-	-	-	-	-	-	4 942	44 269	-	-
Pacific Maritime	21 898	-	-	-	-	-	-	-	-	-	21 898	-	-
Boreal Cordillera	46 460	-	-	-	-	-	-	-	-	-	14 741	31 719	-
Tundra Cordillera	26 484	-	-	-	-	-	-	-	-	-	-	16 405	10 079
Taiga Plains	64 700	-	-	-	-	-	-	-	-	9 268	4 380	1 831	49 222
Taiga Shield	136 640	20 466	-	-	-	53 254	-	10 228	5 486	807	-	-	46 399
Hudson Plains	36 236	-	-	-	-	2 432	24 854	8 662	-	-	-	-	288
Southern Arctic	83 239	4 600	-	-	-	12 392	-	169	-	-	-	-	66 078
Northern Arctic	151 088	-	-	-	-	7 106	-	-	-	-	-	-	143 982
Arctic Cordillera	25 059	975	-	-	-	725	-	-	-	-	-	-	23 359
Total	**997 061**	**40 802**	**706**	**6 918**	**9 156**	**159 452**	**106 863**	**62 198**	**60 304**	**62 561**	**95 654**	**52 877**	**339 571**

Ecozone	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	percent of area												
Atlantic Maritime	2.0	-	100.0	100.0	100.0	2.3	-	-	-	-	-	-	-
Mixed Wood Plains	2.0	-	-	-	-	4.4	11.6	-	-	-	-	-	-
Boreal Shield	19.5	36.2	-	-	-	45.7	65.2	44.5	16.1	-	-	-	-
Prairies	4.8	-	-	-	-	-	-	10.9	43.3	23.8	-	-	-
Boreal Plains	7.4	-	-	-	-	-	-	14.0	31.5	52.2	10.8	5.5	--
Montaine Cordillera	4.9	-	-	-	-	-	-	-	-	7.9	46.3	-	-
Pacific Maritime	2.2	-	-	-	-	-	-	-	-	-	22.9	-	-
Boreal Cordillera	4.7	-	-	-	-	-	-	-	-	-	15.4	60.0	-
Tundra Cordillera	2.7	-	-	-	-	-	-	-	-	-	-	31.0	3.0
Taiga Plains	6.5	-	-	-	-	-	-	-	-	14.8	4.6	3.5	14.5
Taiga Shield	13.7	50.2	-	-	-	33.4	-	16.4	9.1	1.3	-	-	13.7
Hudson Plains	3.6	-	-	-	-	1.5	23.3	13.9	-	-	-	-	0.1
Southern Arctic	8.3	11.3	-	-	-	7.8	-	0.3	-	-	-	-	19.5
Northern Arctic	15.2	-	-	-	-	4.5	-	-	-	-	-	-	42.4
Arctic Cordillera	2.5	2.4	-	-	-	0.5	-	-	-	-	-	-	6.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Notes:
Figures may not add due to rounding.
Numbers have been adjusted to match Environment Canada's totals.
Sources:
Environment Canada, Agriculture and Agri-Food Canada, National Ecological Framework.

Provincial Governments: Several provinces have developed or are in the process of developing sophisticated land-use monitoring programs. For example, British Columbia has recently introduced Regional Land-use Plans for several key areas: Vancouver Island, the Cariboo-Chilcotin region in central British Columbia, and the Kootenay-Boundary Region in southeastern British Columbia.

New Brunswick has recently produced a detailed land-cover/land-use map in digital form. This was assembled from their forest inventory database (New Brunswick Natural Resources and Energy, 1996).

Statistics Canada – Land Accounting, *Census of Agriculture, Human Activity and the Environment, Environmental Perspectives*: Statistics Canada has a substantial history in integrating and reporting on land information. The *Census of Agriculture* is one of the primary sources of information on agricultural land and management practices. Since 1978, publications such as *Human Activity and the Environment* have been bringing together information on land use and land cover.

Statistics Canada has recently begun developing a Land Account which would more systematically deal with classifications and data on land. Some of the most recent results are reported in this volume. Chapter 8 applies land-cover data generated from satellite imagery (Energy, Mines and Resources Canada, 1993) to understanding land use in New Brunswick. Also for New Brunswick, Chapter 9 investigates an environmental-economics approach to determining an alternative definition of "agricultural land value". Previous outputs included a land accounting approach applied to the assessment of environmental changes around Waterton Lakes National Park in Alberta (Trant *et al.*, 1995).

Table 7.4

Land Cover Estimates Based on NRCan Vegetation Cover, 1988-1991

Cover class	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	thousand hectares												
Mixed forest	108 104	4 098	127	1 328	4 188	24 830	25 368	3 188	4 491	14 131	14 443	789	11 123
Broadleaf forest	29 630	-	41	869	951	4 917	2 390	4 415	2 748	9 180	3 451	23	645
Water	51 355	1 873	14	92	76	6 514	12 683	6 636	3 115	1 509	1 773	474	16 595
Transitional forest	134 557	12 769	-	69	-	36 948	23 516	12 954	3 465	-	27	1 963	42 846
Coniferous forest	253 641	11 471	88	2 842	1 903	38 987	37 069	23 521	22 608	17 712	55 703	24 076	17 660
Tundra	136 834	6 268	-	-	-	26 238	-	5 302	1	-	4 973	12 784	81 269
Barren land	167 046	3 177	11	111	98	6 388	13	31	-	1 406	8 474	4 113	143 224
Ice/Snow	18 999	-	-	-	-	-	-	-	-	31	2 133	1 314	15 521
Cropland	50 021	-	321	282	134	3 228	6 193	5 910	20 846	12 570	537	-	-
Rangeland	14 670	-	-	-	-	-	-	684	5 918	7 422	646	-	-
Built-up area	507	8	1	22	12	73	181	29	15	80	84	-	1
Total Area	**965 364**	**39 664**	**604**	**5 616**	**7 363**	**148 123**	**107 413**	**62 670**	**63 207**	**64 041**	**92 243**	**45 536**	**328 885**
Land	914 009	37 791	590	5 524	7 287	141 609	94 730	56 034	60 092	62 532	90 470	45 062	312 290
Water	51 355	1 873	14	92	76	6 514	12 683	6 636	3 115	1 509	1 773	474	16 595

Cover class	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	percent												
Mixed forest	11	10	21	24	57	17	24	5	7	22	16	2	3
Broadleaf forest	3	-	7	16	13	3	2	7	4	14	4	0	0
Water	5	5	2	2	1	4	12	11	5	2	2	1	5
Transitional forest	14	32	-	1	-	25	22	21	6	-	--	4	13
Coniferous forest	26	29	15	51	26	26	34	38	36	28	60	53	5
Tundra	14	16	-	-	-	18	-	8	--	-	5	28	25
Barren land	17	8	2	2	1	4	--	--	-	2	9	9	44
Ice/Snow	2	-	-	-	-	-	-	-	-	--	2	3	5
Cropland	5	-	53	5	2	2	6	9	33	20	1	-	-
Rangeland	2	-	-	-	-	-	-	1	9	12	1	-	-
Built-up area	0	--	-	0	0	--	0	--	--	0	0	-	--
Total Area	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Land	95	95	98	98	99	96	88	89	95	98	98	99	95
Water	5	5	2	2	1	4	12	11	5	2	2	1	5

Note:
Figures may not add due to rounding.
Source:
Natural Resources Canada, National Atlas.

Statistics Canada/Environment Canada – National Urban Land Information Base (NULIB): The objective of NULIB is to develop a standardized, nationally-consistent environmental database to determine land use and land-use change statistics for the urban and urban-fringe regions of Canada using high-resolution satellite imagery. The program identifies:

- changes in urban land activity (1986 to 1991);
- broad land-cover information (wooded vegetation, non-wooded vegetation, water and non-vegetated surfaces); and
- the amount and distribution of green space within the urban core.

NULIB began with a pilot study of the Ottawa-Hull Census Metropolitan Area (CMA) to determine the optimal image, processing and methodology steps required to meet the program objectives (Statistics Canada and Environment Canada, 1993). The pilot clearly demonstrated that high-resolution satellite imagery could provide land use and land-use change information for the urban and rural-fringe in an accurate and cost-effective manner. With further funding obtained since the pilot study, operational processing of other CMAs had been completed. These urban centres include Toronto, Vancouver (Map 7.6), Victoria, Montréal, Québec, Halifax, London and Saskatoon.

NULIB products facilitate the analysis of land-use change between CLUMP 1986 and NULIB 1991, prediction of land-use trends, monitoring of green space within the urban core, and evaluation of government programs which have an impact on land use, national land budgeting and resource planning. The next stage for NULIB involves seeking additional funding partners for the processing of remaining CMAs and updating the database on a regular cyclical basis.

Statistics Canada/Pest Management Regulatory Agency – The Delineation Of Agricultural Field-trial Regions: The chemical registration process requires that field-trial studies be conducted in regions that have crops, soils, climatic and other bio-physical parameters that are representative of the regions where the new chemicals are intended

for use. In order to reduce the cost and time to register products, NAFTA agreements state that Canada and the United States accept the results of field studies conducted in regions that have similar characteristics in either country. The objective of this project was to develop a methodology to delineate field-trial regions for Canada while also retaining, wherever possible, regions that correspond to the previously delineated U.S. field-trial regions.

The delineation of the field-trial regions first required development of Canadian coverages that depict where crops are currently grown (and which crops are growing where) and where crops could be grown (arable land). Current crop maps were derived from the Statistics Canada's Agriculture Ecumene of Canada and *1991 Census of Agriculture*. Many data sources from various federal departments were used to delineate the field-trial regions; the most important included:

- Terrestrial Ecozones and Ecoregions of Canada (Environment Canada);
- Soil Landscape of Canada Database (Agriculture and Agri-Food Canada);
- Soils of Canada Map (Agriculture and Agri-Food Canada);
- Canada Land Inventory for Agriculture (Agriculture and Agri-Food Canada);
- National Atlas (Natural Resources Canada);
- Ecoclimatic Regions of Canada Map (Environment Canada);
- Level II Ecological Regions of North America - Draft (Agriculture and Agri-Food Canada);
- Climatic Characteristics of Canada (Natural Resources Canada);
- Crop Maps (Statistics Canada); and
- Agriculture Ecumene of Canada (Statistics Canada).

This project highlights an application that has required considerable interaction and cooperation of four federal departments and numerous contacts in provincial departments and other agencies. As well, U.S. counterparts responsible for delineation of the American field-trial regions were consulted. The resulting maps (Map 7.7 for example) and digital coverages include Canadian and North American level major and minor field-trial regions.

International activities

Canada is noted internationally for the quality of its agricultural and forestry statistics. Other countries have made substantial progress in assembling general national perspectives on land and in linking that information to policy decisions. Examples are given here for the land accounting activities of the European Community, Germany, France, the Netherlands and the United Kingdom.

The European Community

In 1985, the European Community initiated the Coordination of Information on the Environment (CORINE) program. The objective of CORINE is to develop a framework for the collection, coordination and harmonization of information on the state of the environment and the natural resources in the Community. The data collection permits a stock of land-use data to be visualized as a computer map. Today, CORINE represents the environmental information system of the European Union—a system based on land-cover and land-use geographical data for all of Europe. A task force which is in charge of the CORINE Information System has been created within the Commission of the European Community's Directorate General for the Environment (Federal Statistical Office of Germany, 1990).

CORINE data are based on satellite images, topographical maps and aerial photographs. Land is classified into 44 categories of land use and cover, with the smallest unit covering 25 hectares. The entire CORINE project is expected to cover 2.3 million km^2 in 12 countries, at a scale of 1 : 100 000. Each country within Europe will eventually work towards implementing CORINE using a method particular to its own area (Institut français de l'environnement, 1994a).

Germany

In the Federal Republic of Germany, land statistics are collected for data mapping through CORINE and the Statistical Information System on Land Use (STABIS). Using STABIS, land-use/land-cover maps will be created for three different dates (1952, 1972, 1992), while only two different land-cover/land-use maps (1984, 1992) can be created using CORINE. From these data, a system will be set up for accounting for land use/land cover. Stock accounts will be available for certain periods and flow accounts will show changes in stocks between periods. The effects of natural processes and human activity on land cover/land use will also be estimated, with an analysis of the interaction between economic activity and land use. Currently a pilot project is being carried out to test the applicability and procedure of using CORINE (Federal Statistical Office of Germany, 1994).

France

In France, CORINE is accompanied by Ter-Uti as a data source for land-cover accounting. Ter-Uti is an annual land-use survey which is based on remote sensing and conducted mainly to monitor agricultural land. Similar accounts to those described for Germany will be created wherein

land-use/land-cover change data will be presented in matrix form (Institut français de l'environnement, 1994b).

The Netherlands

Data pertaining to land cover/land use have been entered into a GIS for selected years. Changes in land cover/land use will be analysed and presented in table or matrix format for 35 land categories.

The land accounting procedure in The Netherlands will also incorporate land valuation. Land is classified according to 35 categories of mixed land use and land cover. The accounting procedure will place a value on land categorized under this classification scheme and values will be entered as part of the first National Balance Sheet for the Netherlands. Such values are averages of values provided through a survey of municipalities.

The United Kingdom

Information on land cover, landscape features and habitats in Great Britain is provided by the Countryside Survey (CS), carried out in 1990 by the Institute of Terrestrial Ecology (ITE). This survey identifies land change by reference to earlier surveys, and establishes a new baseline for the measurement of future change. The land classes used in the CS1990 field survey will be linked with the ITE's 17 land-cover map classes and those of CORINE to produce a CORINE land-cover map for Great Britain. Land-cover change matrices will continue to be produced.

Detailed changes in land use are studied frequently by the Department of the Environment in Great Britain, with such statistics being suited to analyses of changes to urban and rural uses and of the recycling of land. The classification for recording land-use change is based on 24 separate categories of land use, which are combined under the divisions of "urban" and "rural" uses (United Kingdom Department of the Environment, 1994).

Estimating land cover and land use for Canada

Two key elements of land statistics are the cover and the use of the land. Land cover is what can be seen on the land. This is not always directly associated with a specific use. The cover may be "coniferous trees" but the use can be either "production forest" or "conservation area". Land use is traditionally defined as the uses humans make of the land (residential, commercial, industrial, forestry, agriculture, and mining, etc.). To understand the effects our human activities are having on the land and its support functions, it is useful to have detailed information on changes in land cover and land use over time.

An initial assessment of the national and provincial data shows that there is a substantial quantity of land statistics in Canada. Much of this exists in disparate datasets in federal and provincial government departments. A comprehensive set of land statistics will require the integration of existing information as well as the estimation of important statistics (such as detailed cover, use, potential, value) that are not measured at the national level.

The proposed framework for the development of land accounts for Canada is based on the estimation of basic land cover, use, potential and value statistics on the level of ecoregion. Statistics on land cover have already been estimated on an ecoregion basis and show that the resolution of the land-cover information results in appropriate estimates at this level.

Land-use information exists for periods in the past (such as from the CLI and CLUMP) but a recent national perspective does not exist. Data are available for certain components of land use (residential, agricultural and forestry) and these will form the basis for a current national land use estimate.

Estimating land cover

Land-cover information for Canada is available for recent years from remote sensing imagery. As shown in Map 7.5, the data were originally synthesized from three years of satellite images. The digital data for this map were tabulated by province, and ecozone. The results are presented in Table 7.4. In this table, the areas of the provinces and territories do not exactly match the official areas. This is mainly due to the resolution of the satellite image. At one kilometre resolution, many of the smaller features (shoreline details, islands, lakes and rivers) are not visible. The estimates for water area and total area will be adjusted using more detailed shoreline and hydrographic data.

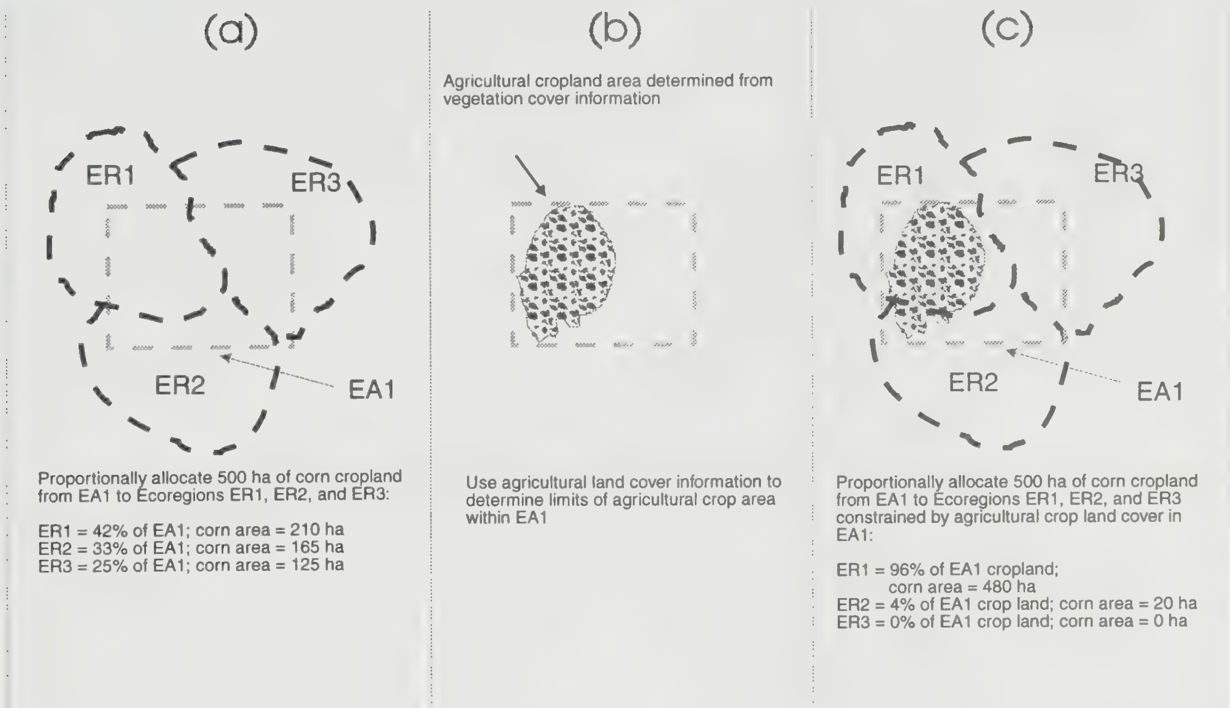
It is not certain that a picture, comparable in scope and detail to the National Atlas Vegetation Cover, could be generated for any period in the past.

Estimating land use

The following methodology is based on proportionally allocating land-use statistics between geostatistical areas and environmental geographies. The first stage allocates data on Census Enumeration Areas (EAs) to ecoregions. This poses some problems in that EAs do not always fit into ecoregions. In urban areas, EAs are relatively small compared to ecoregions. However in rural regions, one EA may span several ecoregions (Statistics Canada, 1994).The distribution of agricultural land within the EA is not known from the *Census of Agriculture*. Therefore, simple proportional allocation introduces statistical figments into the ecoregion estimates. In Figure 7.1a, for example, an initial estimate would allocate 42% of the area of corn planted in EA1 to Ecoregion 1, 33% to Ecoregion 2 and 25% to Ecoregion 3. It is unlikely that agricultural land is evenly distributed within the EA.

The location of agricultural crop area within EAs can be determined more accurately by superimposing land-cover and land-potential information. Figure 7.1b shows the distribu-

Figure 7.1
Example of Using Land Cover Data to Determine Extent of Land Use



tion of agricultural crop area within EA1 derived from a satellite image. By applying the land-cover information, the allocation of crop area to ecoregion is improved. Figure 7.1c shows that since most of the crop area of EA1 was in Ecoregion 1, this ecoregion receives a greater share of the area of corn.

For each of the 217 ecoregions in Canada, it is possible to use this general approach to estimate land use according to the following classes.

- **Urban**: For Urban EAs[1], the total area of the as EA is considered as urban. When EAs straddle an ecoregion boundary, the urban area is proportionally allocated between overlapping ecoregions. Map 7.8 shows the distribution of Canada's population for 1991. Each dot represents about 300 persons.
- **Agriculture**: From the *Census of Agriculture*, major agricultural land-use classes (cropland, summerfallow, improved pasture) are calculated for EAs and assigned to ecoregions. Areas are proportionally allocated between ecoregions when EAs straddle an ecoregion boundary. Vegetation cover information is used to assign agricultural land use within large EAs and to cross-check statistics within ecoregions.
- **Forestry**: Canada's Forest Inventory assembles information for about 48 thousand map cells. The major forest land category information is aggregated from these cells to ecoregions. Vegetation cover information on forest type is used to allocate forested area within large map cells.
- **Other**: This class is characteristically large during this first approximation.

This approach generates a database of approximately eight land-use types and eight land-cover types for each ecoregion. Other useful statistics are also available at this level. Data on population, occupation, dwellings, and agricultural details (such as land value, major crop type, quantities of fertilizer applied) have been estimated for each ecoregion.

Initially, this database has been created using 1991 information. It allows an initial estimation of land use by province and ecoregion. The estimate will also be performed for 1981 thereby providing a basis for estimating land-use change over the decade.

Future work

The next stage in developing the Land Account will incorporate data on other land uses such as wildlife sanctuaries, transportation, industry, mines, and wetlands. It is also expected that some estimates, such as detailed land use and land cover can be derived from provincial inventories.

The Canada Land Inventory will be applied to provide a perspective on land potential. Besides assessing land potential, the CLI also classified the land as to the reason for a limitation for a specific use. For example, if a tract of land was in Class 3 (moderate to severe limitations), the reason for not being in Class 1 (prime agricultural land) could be specified as "unsuitable climate". This information can be

1. An urban EA is defined in Statistics Canada's *1991 Census of Population* as having a population of 1 000 or greater and a population density of more than 400 persons per km^2.

applied to each ecoregion to estimate limitations for particular land uses.

More detailed forest inventory data are available from certain provinces such as New Brunswick and British Columbia. Similarly, more detailed land-use, value and ownership data are available from municipal registries. These are only beginning to become available in digital format.

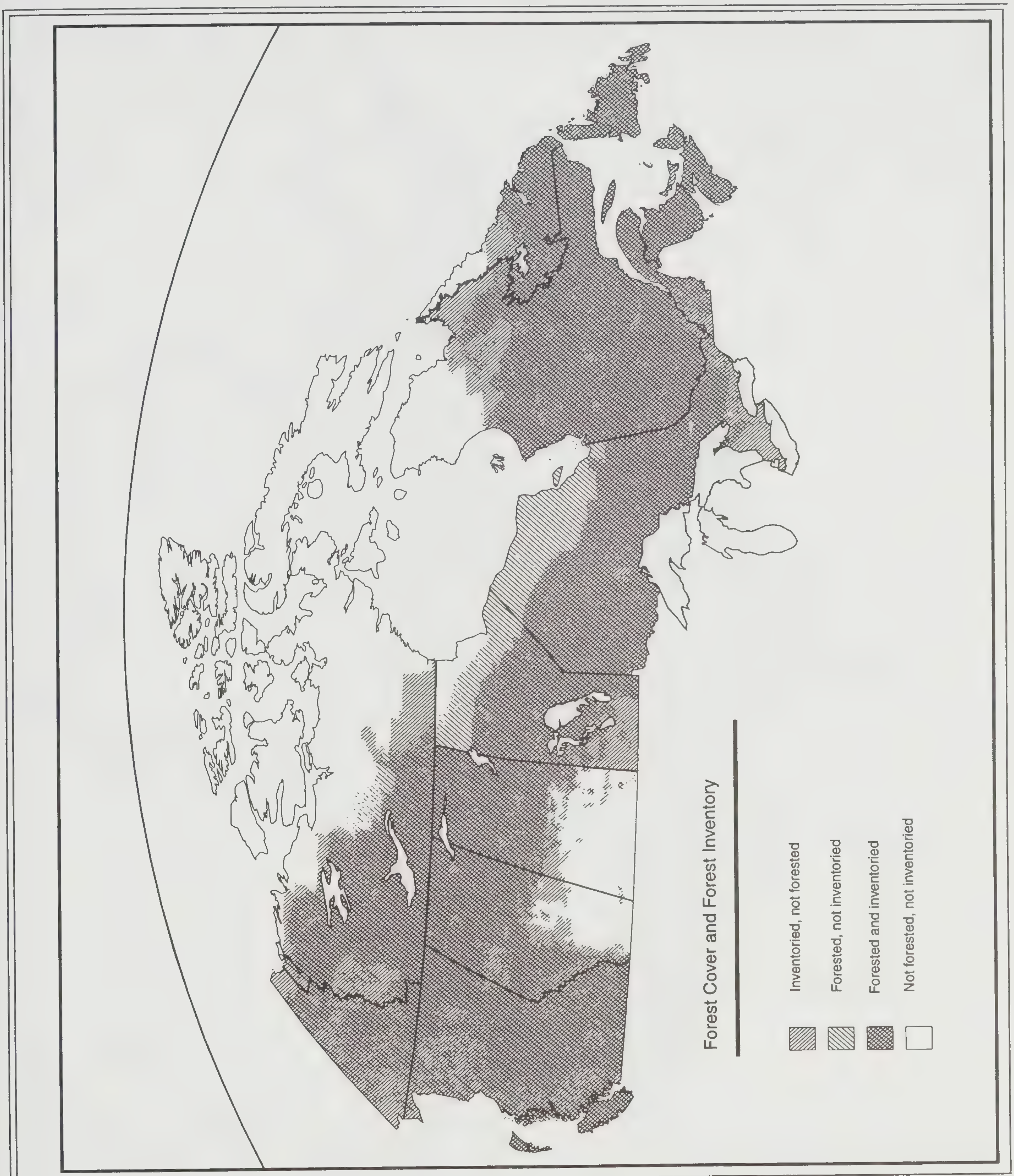
Other sources of land information which will be investigated for inclusion in the Statistics Canada Land Account include: street networks (Statistics Canada), Digital Chart of the World (Environmental Systems Research Institute, ESRI), and the Conservation Areas Database (Environment Canada). These will not only enhance the richness of data in the account but also help improve the quality and detail of future estimates.

Conclusion

Land information provides a valuable basis for many environmental, economic and scientific policy issues. Collecting land information at the national level has not been a priority since land is mainly a provincial jurisdiction. Past approaches have been expensive and labour-intensive. Statistics Canada's Land Accounting program will develop many key national-level land statistics through the assembly of existing information.

Map 7.2

Forest Cover and Forest Inventory, 1991



Sources:
Natural Resources Canada, Canadian Forestry Service and National Atlas.

Map 7.3
Land Classification from Land Potential Database, 1991

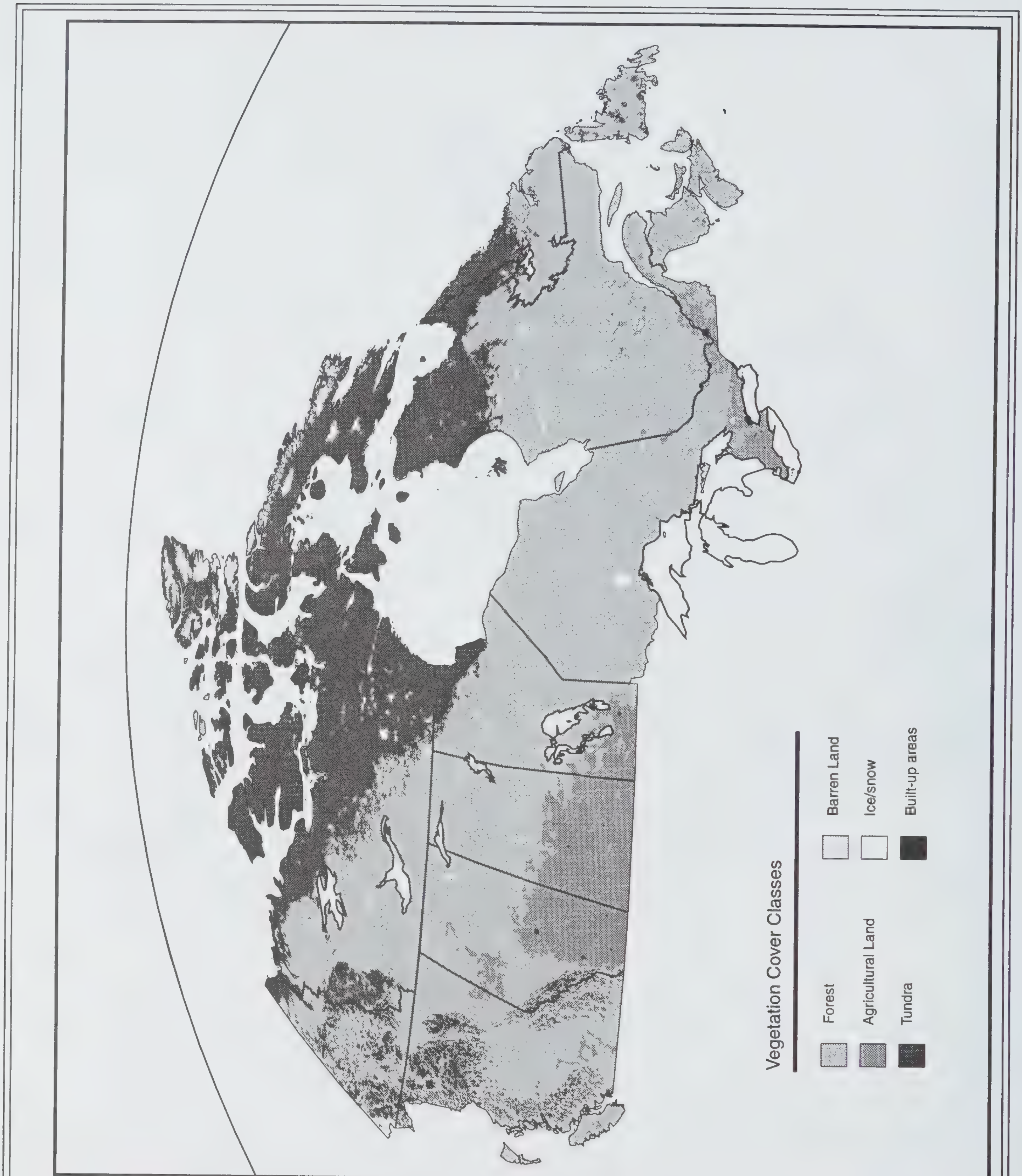
Sources:
Agriculture and Agri-food Canada, Land Resource Research Centre.

Map 7.4
Terrestrial Ecozones

Source:
Ecological Stratification Working Group, 1995.

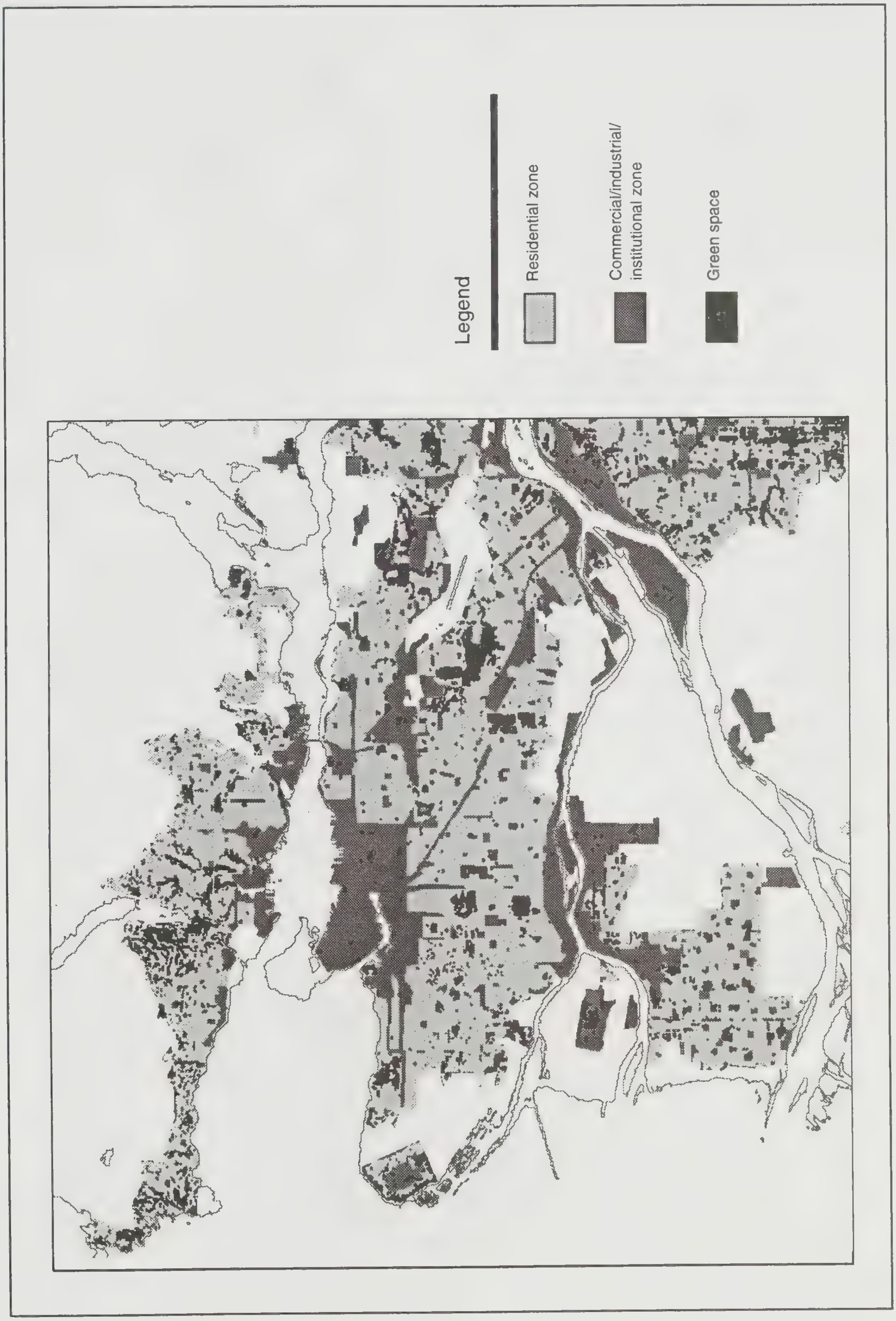
Map 7.5

Vegetation Cover, Composite 1988-1991



Source:
Natural Resources Canada, National Atlas of Canada.

Map 7.6
Vancouver Green Space Within an Urban Environment, 1991



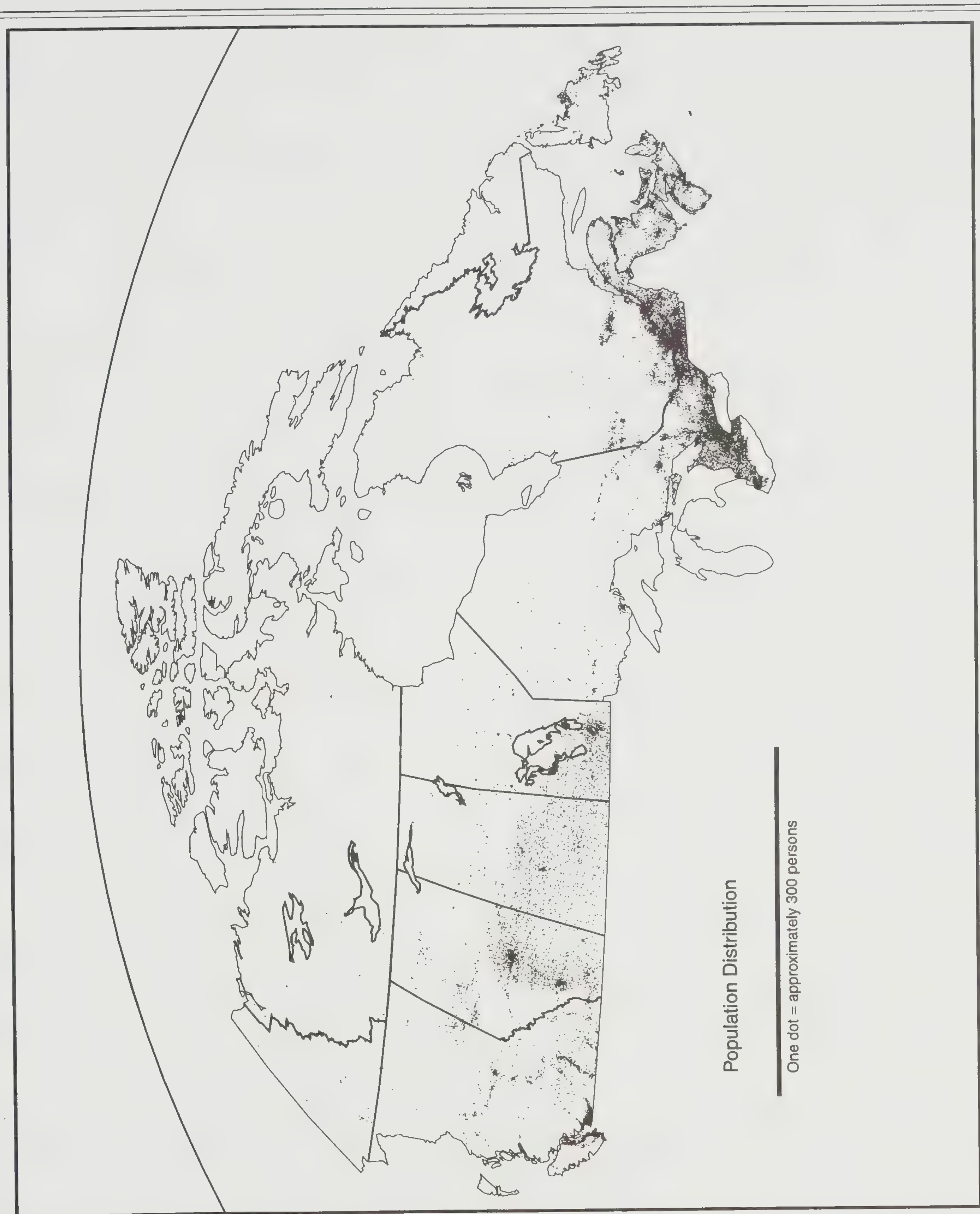
Source:
Statistics Canada, Agriculture Division, National Urban Land Information Base, Spatial Analysis and Geomatics Applications.

Map 7.7
Major and Minor Crop Field Trial Regions

Source:
Statistics Canada, Agriculture Division, National Urban Land Information Base, Spatial Analysis and Geomatics Applications. Prepared for Pest Management Regulatory Agency, Health Canada.

Map 7.8

Population Distribution, 1991



Sources:
Statistics Canada, Census of Population and National Accounts and Environment Division

References

Agriculture Canada, 1991, *Soil Landscapes of Canada: Procedures Manual and User's Handbook,* Cat. No. A53-1868/1991E, Ottawa.

Canadian Council of Forest Ministers, 1994, *Compendium of Canadian Forestry Statistics 1993*, Cat. No. Fo1-8/1993E, Ottawa.

Ecological Stratification Working Group, 1995, *Ecoregions of Canada,* Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ottawa.

Energy, Mines and Resources Canada, 1968, *Waterfront Land Use in Metropolitan Vancouver, B.C.*, Charles N. Forward, Geographical Branch Geographical Paper No. 41, Ottawa.

_____, 1969a, *The Planning Challenge in the Ottawa Area,* Alice Coleman, Geographical Branch Geographical Paper No. 42, Ottawa.

_____, 1969b, *Land Use of the Victoria B.C. Area,* Charles N. Forward, Geographical Branch Geographical Paper No. 43, Ottawa.

_____, 1970, *Impact of Industrial Incentives: Southern Georgian Bay Region, Ontario,* M. H. Yeates and Peter E. Lloyd, Geographical Branch Geographical Paper No. 44, Ottawa.

_____, 1993, *The National Atlas of Canada*, Ottawa.

Environment Canada, 1973a, *Gulf of St. Lawrence, Water Uses and Related Activities*, Wendy Simpson, Lands Directorate Geographical Paper No. 53, Ottawa.

_____, 1973b, *Aspects of Agricultural Land Use in Prince Edward Island*, L. F. Bradley and Andrée Beaulieu, Lands Directorate Geographical Paper No. 54, Ottawa.

_____, 1974a, *Landowners and Land Use in the Musquodoboit Valley, Nova Scotia*, D. K. Redpath, Lands Directorate Geographical Paper No. 55, Ottawa.

_____, 1974b, *Water Resources and Related Land Uses, Straits of Georgia-Puget Sound Basin*, Dr. Mary L. Barker, Lands Directorate Geographical Paper No. 56, Ottawa.

_____, 1977, *Land Use Programs in Canada: Ontario*, Lands Directorate, Ottawa.

_____, 1980, *Land Use in Canada*, Lands Directorate, Cat. No. En72-7/1980, Ottawa.

_____, 1981, *Canada Land Inventory: Land Capability for Wildlife - Waterfowl Summary Report*, The Canada Land Inventory Report No. 16, Ottawa.

_____, 1982, *Mining, Land Use and the Environment: A Canadian Overview*, Environment Canada, Lands Directorate, Cat. No. En73-1/22E, Ottawa.

_____, 1986, *State of the Environment Report for Canada*, Cat. No. En21-54/1986, Ottawa.

Federal/Provincial Committee on Land Use, 1996, *Perspectives on Land Use Issues in Canada, August 1995*, unpublished forum summary.

Federal Statistical Office of Germany, 1990, *Methods, Approaches and Developments*, Wiesbaden.

_____, 1994, *Land Use/Land Cover Accounting*, Wiesbaden.

Government of Canada, 1981, *Federal Policy on Land Use*, Cat. No. En72-9/1981E, Ottawa.

_____, 1990, *Canada's Green Plan*, Ottawa.

_____, 1992, *The State of Canada's Environment*, Cat. No. En21-54/1991E, Ottawa.

_____, 1995, *A Guide to Green Government*, Cat. No. En21-136/1995E, Ottawa.

Gray, S. L. and Neitman, K., 1989, *Canada's Forest Inventory 1986 –Technical Supplement, Information Report P1-X-86E*, Petawawa National Forestry Institute, Chalk River, Ontario.

Institut français de l'environnement, 1994a, *Corine land cover – Technical guide*, European Commission, Luxembourg, p. 14.

_____, 1994b, *CES Task Force on Physical Environmental Accounting – Group on Land Use/Land Cover-French Progress Report*, Luxembourg, p. 4-5.

Natural Resources Canada, Canadian Forest Service, 1995, *The State of Canada's Forests 1994*, Catalogue No. Fo1-6/1995E, Ottawa.

New Brunswick Natural Resources and Energy, 1996, *Forest Development Survey*, Forest Management Branch, Fredericton.

Post-BOREAS Task Group, 1995, *Canadian Land Processes Research in the Post-Boreas Period*, Report to the Canadian BOREAS Coordinating Committee, August 1995, unpublished.

Statistics Canada, 1981, *Report of the Working Group on Land Statistics*, Office of the Senior Advisor on Integration, June 1981, Ottawa.

_____, 1994, *Human Activity and the Environment*, Cat. No. 11-509E, Ottawa.

_____, 1995, *National Balance Sheet Accounts,* Cat. No. 13-214, Ottawa.

Statistics Canada and Environment Canada, 1993, *Development of an Urban Land Information Base from Digital Satellite Imagery,* uncatalogued discussion paper, Ottawa.

Trant, Douglas, 1993, "Land Use Change Around Riding Mountain National Park", *Environmental Perspectives: Studies and Statistics,* Statistics Canada, Cat. No. 11-528E, Ottawa.

Trant, Douglas, Christine DeBoer and Kevin Van Tieghem, 1995, "Environmental Change Around Waterton Lakes National Park", *Environmental Perspectives: Studies and Statistics*, Statistics Canada, Cat. No. 11-528E, No. 2, Ottawa.

Turner, B. L., R. H. Moss and D. L. Skole, 1993, *Relating Land Use and Global Land-cover Change: A Proposal for an IGBP-HDP Core Project*, Stockholm.

United Kingdom Department of the Environment, 1994, *Land Use Change in England, No. 9*, London, England.

Wackernagel, Mathis, 1993, *How BIG is Our Ecological Footprint, Using the Concept of Appropriated Carrying Capacity for Measuring Sustainability,* The Task Force on Planning Healthy and Sustainable Communities, The University of British Columbia, Vancouver.

Wiken, Ed, 1986, *Terrestrial Ecozones of Canada,* Ecological Classification Series No. 19, Environment Canada, Lands Directorate, Cat. No. En7303/19, Ottawa.

8 Pilot Land Accounts for New Brunswick

by Douglas Trant and Giuseppe Filoso

Introduction

Canada is the second largest country in the world with an area of more than 9.97 million square kilometres. If Canada's population was distributed evenly across this area there would be fewer than three people per square kilometre. Despite Canada's size, 90% of Canadians live in a narrow band along its southern border where population densities can exceed 1 000 people per square kilometre in larger urban centres.[1] Land use competition is intense in this corridor and this is reflected in high land values and rapidly changing land uses. In Toronto, Canada's largest city, land values in the central business district have ranged as high as $12 500 per square metre.[2]

Most human activities use land: agriculture, forestry, transportation, trade and housing. Table 8.1 provides a snapshot of how Canada's land was used in 1985.

Table 8.1 indicates that most of Canada is not intensively used. Only one percent of land area is used for the most intense urban/industrial land use, while only seven percent is used for agriculture the next most intense use category.

Sixty five percent of Canada's area is wilderness.[3] (This definition of wilderness refers to land that shows no indication of development but may be used for hunting or forest harvest). Wilderness abounds in Canada because much of the country has little or no land use competition. This is due primarily to physiographic and climatic factors that make much of the country unsuitable for economic development and settlement.

Land use conflicts are most prevalent in Canada's southern populated areas. Here data on changing land cover and use can provide excellent environmental indicators for important issues such as changing wildlife habitats, land degradation and many others. Spatially accurate and temporally consistent information on land is essential to quantify the impacts of human activity on biodiversity and to provide answers to long term sustainability questions.

For some time now Canada has not had a national program to look at land use issues (see Chapter 7). Statistics Canada's Land Accounting Program should help fill this gap. The main goal of the land accounts is to provide an integrated set of land statistics which is consistent nationally and updated annually.

Table 8.1
Economic Land Uses in Canada, 1985

Land use category	Description	Area[1]	Share of total
		thousand km²	percent
Forestry	Active forest harvesting or potential for future harvest	2 440	24
Recreation and conservation	Recreation and conservation within national, provincial and territorial parks, wildlife reserves, sanctuaries, etc.	708	7
Agriculture	Agriculture on improved farmland (cropland, improved pasture, summerfallow) and unimproved farmland	678	7
Urban/industrial[2]	Residential and industrial activities of urban environments	72	1
Other activities	Includes hunting and trapping, mining, energy developments and transportation	6 072	61
Total		**9 970**	**100**

Notes:
1. Includes the area of all land and fresh water.
2. Includes only the 25 major metropolitan areas.
Source:
Government of Canada, 1991.

The land accounts are being developed on a geographic information system (GIS) platform, which will facilitate analysis of issues at geographic levels ranging from local to national.

The development of detailed land accounts will harmonize data now collected by numerous jurisdictions and for many different purposes. For example, many of the provinces and territories have their own land use classifications. Much of the land tenure and land use information resides within the registry offices in thousands of municipalities across the country. A national land classification is required to permit comparisons among jurisdictions and to utilize information from a variety of sources.

At the national level, these data will support comparative descriptions and analyses of land use patterns. For example, the benefits and costs associated with converting agricultural land to urban land can be evaluated, this same information can then be used to assess important environmental issues such as long-term sustainability and biodiversity.

This report will present currently compiled land accounts for the province of New Brunswick, and will discuss conceptual and methodological issues that relate to this process.

1. Statistics Canada, 1994, p. 54.
2. Regional Assessment Commission, Ontario Ministry of Finance.
3. World Resources Institute, 1990, p. 274.

Methodology and data sources

A relatively small portion of Canada was selected for development and testing of methodologies and classifications. New Brunswick was chosen as an ideal test site not only due to its manageable size, but because of its diverse mix of land cover types and uses.

New Brunswick occupies an area of 74 498 km^2, or approximately 0.7% of Canada's total area. Table 8.2 indicates the main land cover types in New Brunswick.

New Brunswick is primarily forestland with pockets of agricultural land and settled areas. This mix of large wilderness areas interspersed with smaller population centres is representative of much of Canada.

At this stage the New Brunswick pilot accounts are being completed by ecoregion at a 1 : 1 million scale. This scale is the most practical level at which to work because much of the contributing information is available at this level of detail.

Data sources for the pilot land accounts project were divided into two main types: 1) digital geographic boundary datasets 2) tabular databases.

Digital geographic datasets

Several digital boundary files were assessed to see if they could provide the required information. When deciding which datasets to use three main factors were considered: 1) comparable datasets should be available at the national level, 2) a dataset must be at a constant scale and 3) a dataset should have suitable map projection parameters to make it consistent with other information already gathered.

With these criteria in mind, several datasets were identified, these were: 1) the 1991 Vegetation Cover from Natural Resources Canada, 2) the 1991 enumeration areas (EA) from Statistics Canada, 3) the 1994 ecoregion areas from Environment Canada, and 4) the topographic boundary datasets were obtained from the Digital Chart of the World Project (DCW). Text Box 8.1 lists the features available in each digital map.

Table 8.2

Land Cover[1] in New Brunswick, 1992

Land cover category	Area	Share of total
	km^2	percent
Mixed forest	42 009	56
Coniferous forest	18 960	25
Broadleaf forest	9 510	13
Agricultural cropland[2]	1 353	2
Barren land	1 613	2
Water	928	1
Built-up area	125	- -
Total	**74 498**	**100**

Notes:
Figures may not add due to rounding.
1. Land cover is a physical measure which describes what is covering the land surface. Land use data describe activities that are taking place on land. A given parcel of land can have many different land uses.
2. Agricultural cropland areas represented in this table are not consistent with the census cropland areas reported in Table 8.13. The estimates in this table, which are from satellite data, tend to over-estimate cropland areas because open meadow is easily mistaken for forage crops.
Source:
Natural Resources Canada, 1994b.

Text Box 8.1

Feature Class List for Selected Digital Boundary Files

Digital boundary file	Feature class
Vegetation cover	Mixed forest
	Broadleaf forest
	Water
	Coniferous forest
	Barren land
	Agriculture cropland
	Built-up area
Enumeration area cover	Enumeration area boundaries
	Enumeration area centroids
Ecoregion cover	Ecozone boundaries
	Ecoregion boundaries
Digital Chart of the World Cover	Rivers, streams
	Roads
	Railroads
	Land use
	Urban areas
	Inland water bodies

One of the problems with the digital datasets is that the outer boundaries such as shorelines do not overlay exactly. After an initial review of the available shorelines a decision was made to use the New Brunswick's shoreline boundary from the DCW dataset. This dataset has a much higher resolution shoreline and as a result will reproduce statistically valid area estimates.

All other datasets were matched to the DCW shoreline to make them spatially consistent. This was accomplished by using the vector editing capabilities of the GIS.

This study uses Environment Canada's State of the Environment Reporting ecoregions, as the principal geographic frame for land accounting in New Brunswick. Ecoregions represent areas of common biophysical characteristics and are naturally distinct units, making them valuable for monitoring and comparing the relative impact of human activity in each ecoregion. The other advantage these units provide is that they are fixed over time unlike typical administrative or politically bounded areas which can change significantly from one year to the next.

Tabular datasets

In conjunction with the digital boundary datasets, various socio-economic data from Statistics Canada were also used for the pilot. These were: 1) *Census of Agriculture* 1971, 1976, 1981, 1986, 1991, 2) *Census of Population* 1971, 1976, 1981, 1986, 1991. These datasets were aggregated from the enumeration area level to the ecoregion level by overlaying the digital ecoregion boundary with the enumeration area file.

Land cover and socio-economic profiles of New Brunswick and its ecological regions

New Brunswick has a total of seven ecoregions which are all part of the Atlantic Maritime ecozone. These ecoregions are delineated by distinctive sets of non-living (abiotic) and living (biotic) resources that are ecologically related. Changes in land cover and use have major environmental impacts in these ecoregions.

This section will examine each ecoregion in New Brunswick and profile its major land cover attributes. It will also examine a selection of land use indicators that have been derived from census information.

Population size, distribution and density are major factors determining the impact that human activities have on the environment. For this reason it is useful to know actual population counts and the urban/rural composition of a given region. Population trends provide a useful indication of changing environmental stress levels.

Trends in experienced labour force[1] reflect employment patterns in each area. The resource sector sub-totals provided are useful land use indicators in that they reflect employment reliance on land use intensive activities.

Agricultural land areas provide a measure of how intensively a particular area is being cultivated.

Map 8.1 is a digital image of New Brunswick compiled from satellite information.The map divides New Brunswick into seven land cover classes (coniferous forest, broadleaf forest, mixed forest, barren land, cropland, built-up area and water)

New Brunswick occupies a total of 74 498 km^2. Mixed forests cover an area of 42 009 km^2 or 56% of the province while coniferous and broadleaf forests occupy an additional 25% and 13% respectively. New Brunswick is 94% forested.

1. The experienced labour force refers to persons who during the week prior to the census were employed or unemployed, and had worked during the 18 month period leading up to the census. Experienced labour force statistics by ecoregion reflect occupation by place of residence and not occupation by place of work.

As Table 8.3 indicates, the experienced labour force in New Brunswick was more than 350 000 strong in 1991, representing an increase of 17.5% over 1981.

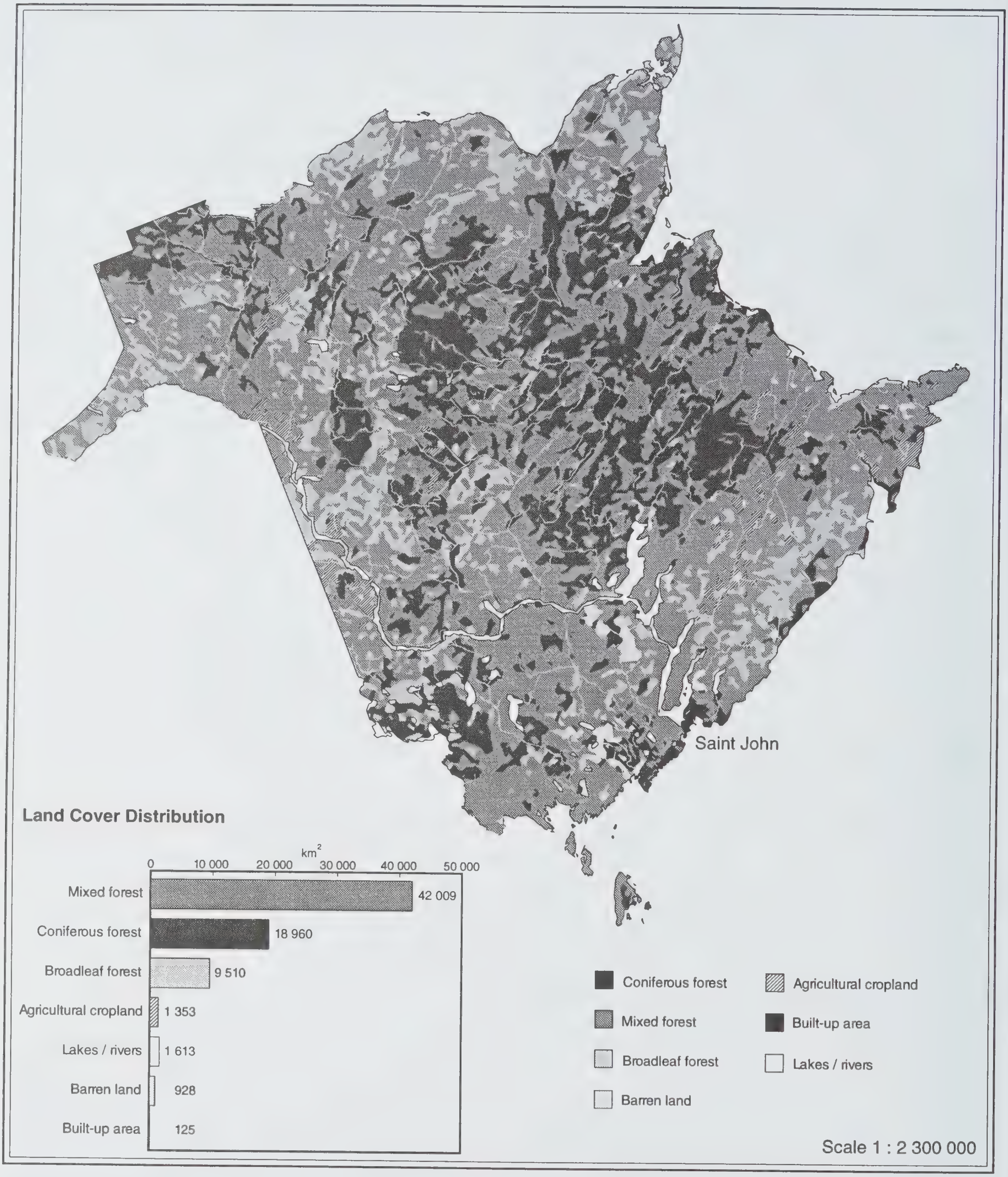
The resource sector of the experienced labour force rose by only 0.2% for the province as a whole between 1981 and 1991.

Table 8.3
Socio-economic Profile of New Brunswick, 1971-1991

	1971	1976	1981	1986	1991	Change 1981-91
			persons			percent
Experienced labour force						
Agriculture	..	..	7 263	8 111	8 154	12.3
Forestry	..	..	9 242	8 752	7 146	-22.7
Fishing and hunting	..	..	3 336	4 315	4 116	23.4
Mining	..	..	3 883	3 978	4 367	12.5
Resource sector	..	..	**23 724**	**25 156**	**23 783**	**0.2**
Manufacturing	..	..	48 156	45 667	46 849	-2.7
Construction	..	..	21 304	21 002	23 552	10.6
Transport and storage	..	..	16 474	17 398	16 189	-1.7
Communication	..	..	6 346	6 040	6 357	0.2
Public utilities	..	..	3 755	3 818	4 758	26.7
Wholesale and retail	..	..	49 173	52 921	57 420	16.8
Finance	..	..	10 510	11 338	12 602	19.9
Services	..	..	80 141	94 675	109 808	37.0
Public administration	..	..	28 121	31 531	35 010	24.5
Not defined	..	..	10 313	9 698	13 774	33.6
Total	..	..	**298 017**	**319 244**	**350 102**	**17.5**
Population	634 557	677 249	696 403	709 442	723 900	3.9
Urban proportion (%)	56.9	52.3	50.7	49.4	47.7	-6.0
Number of farms	5 485	4 551	4 063	3 554	3 252	-20.0
Farmland area (km^2)	5 419	4 668	4 379	4 089	3 756	-14.2

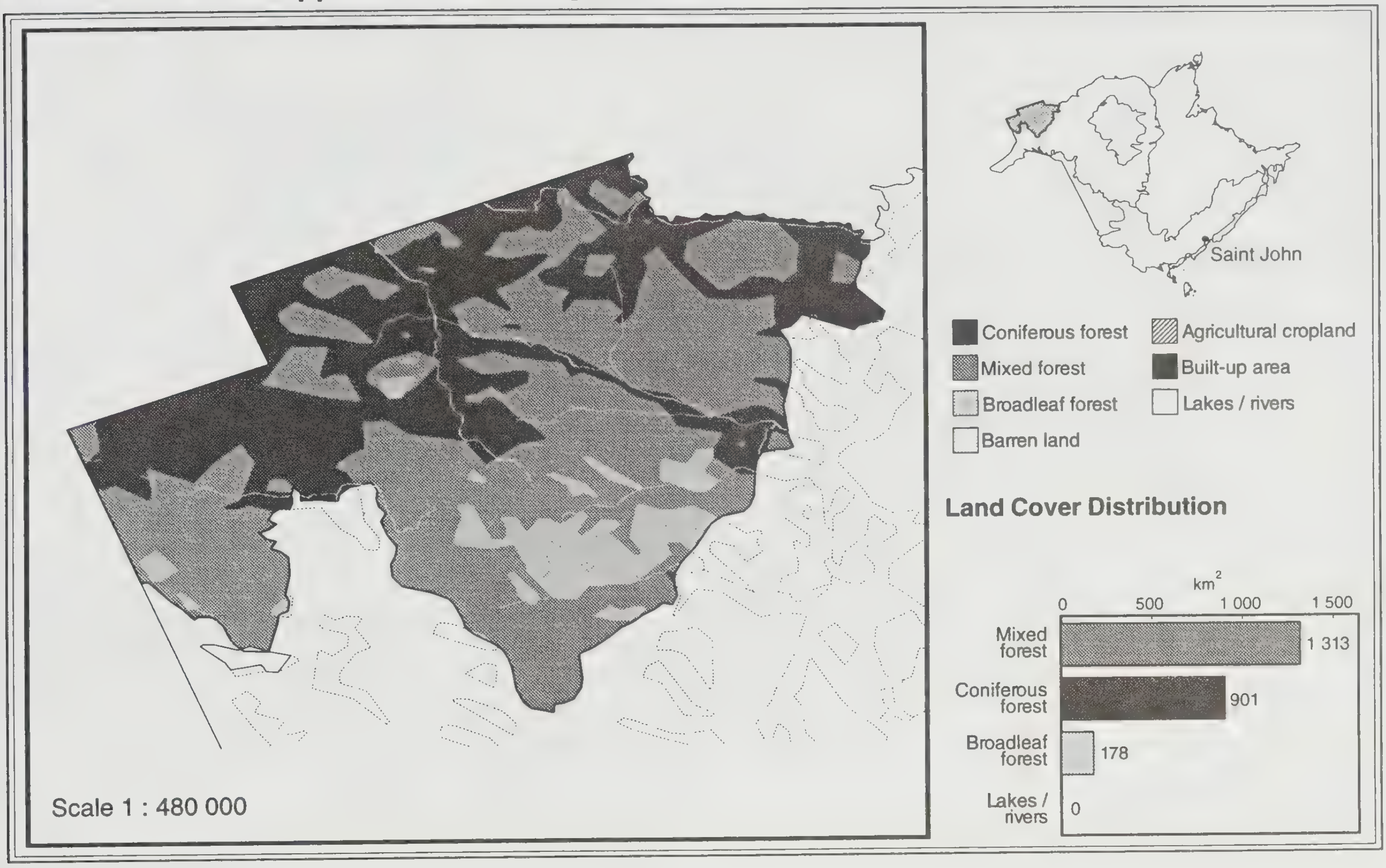
Source:
Statistics Canada, National Accounts and Environment Division.

Map 8.1
Land Cover for New Brunswick, 1992



Source:
Natural Resources Canada, 1994a.

Map 8.2
Land Cover for the Appalachians Ecoregion, 1992



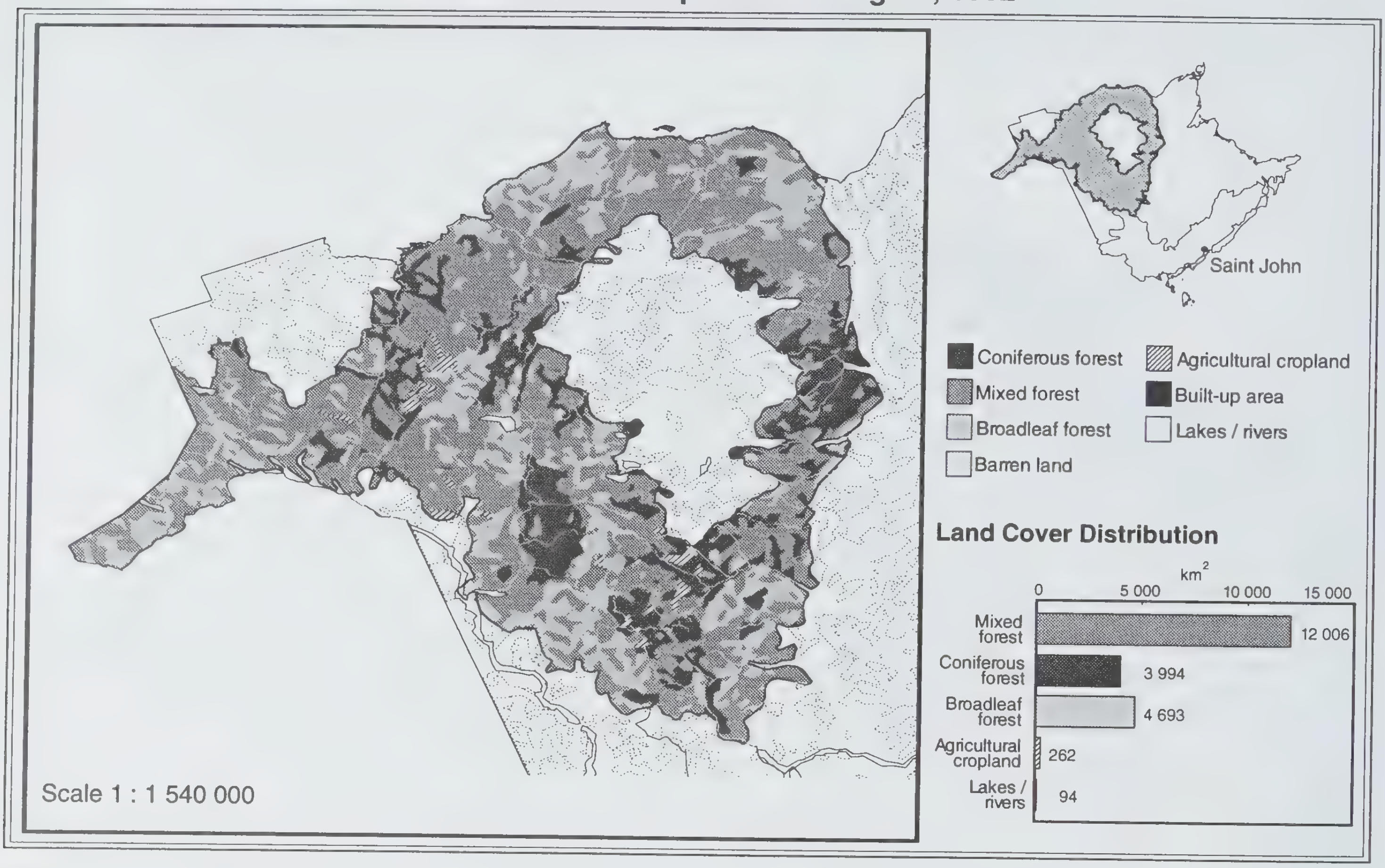
Source:
Natural Resources Canada, 1994a.

The Appalachians Ecoregion

Map 8.2 provides a snapshot of the New Brunswick portion of the Appalachian Ecoregion. This area is mountainous and is primarily wilderness. It has no recorded permanent residents.

The region occupies an area of 2 392 km^2, which represents 3.2% of New Brunswick's land area. Of this total area 1 313 km^2 or 55% is mixed forest, while coniferous and broadleaf stands make up the remaining 45% of the area.

Map 8.3
Land Cover for the Northern New Brunswick Uplands Ecoregion, 1992



Source:
Natural Resources Canada, 1994a.

The Northern New Brunswick Uplands Ecoregion

The Northern New Brunswick Uplands Ecoregion occupies 21 049 km^2 in the northwestern corner of New Brunswick. This region is characterized by rolling hills and large forest stands interspersed with tiny pockets of agricultural land, particularly along river valleys.

In the Northern New Brunswick Uplands, mixed forest covers an area of 12 006 km^2 or 57% of the region while broadleaf and coniferous forests occupy an additional 22% and 19% respectively. The region is 98% forested and contains the majority of New Brunswick's most productive forestland. On average, forest volumes exceed 100 cubic metres per hectare in this region.

The experienced labour force in the region was more than 45 000 strong in 1991, representing an increase of 17% over 1981.

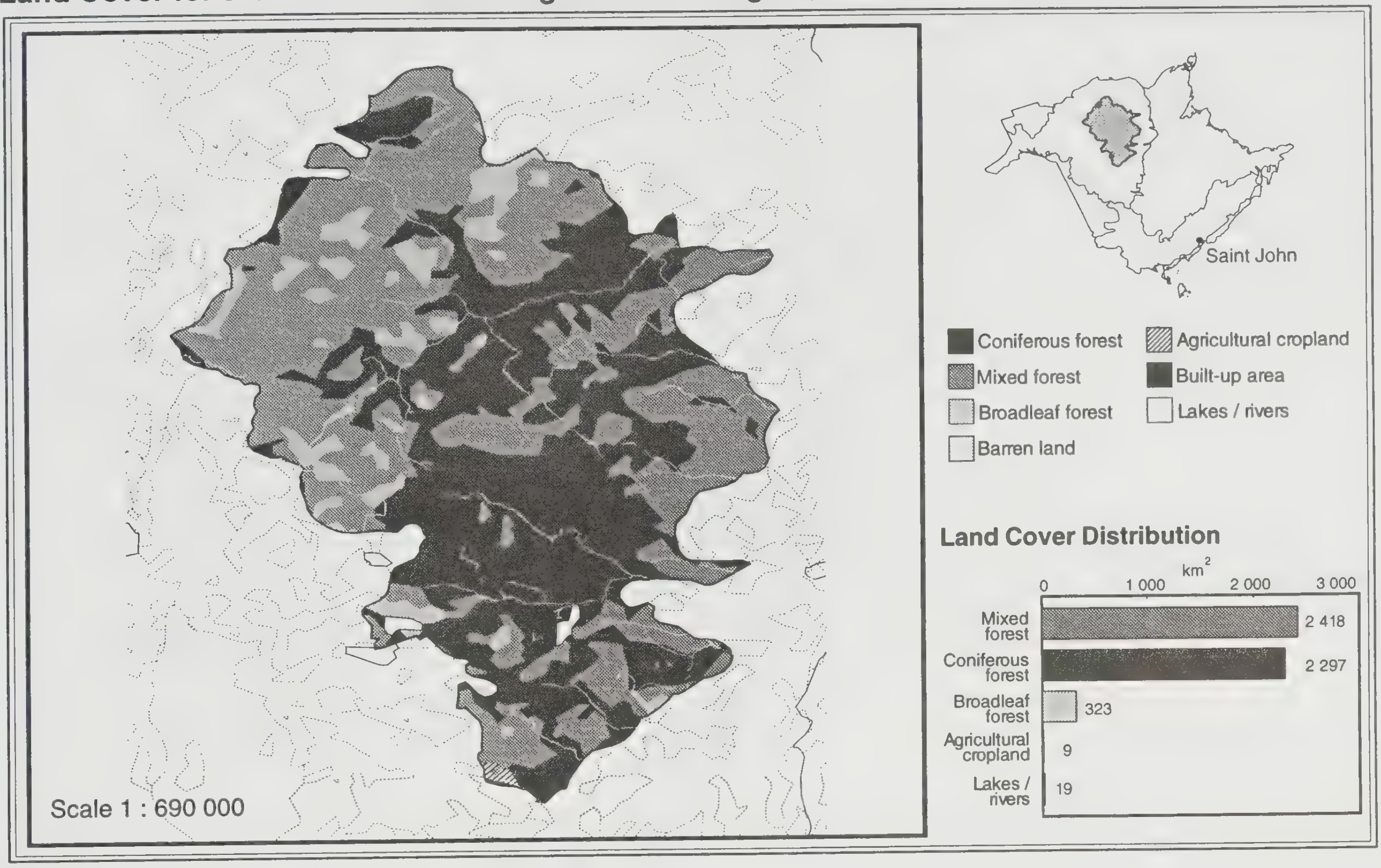
The resource sector of the experienced labour force declined by 3% between 1981 and 1991.

Table 8.4
Socio-economic Profile, 1971-1991

	1971	1976	1981	1986	1991	Change 1981-91
			persons			percent
Experienced labour force						
Agriculture	..	..	1 024	1 127	1 067	4.2
Forestry	..	..	2 471	2 423	2 324	-5.9
Fishing and hunting	..	..	153	136	141	-7.8
Mining	..	..	825	758	778	-5.7
Resource sector	**..**	**..**	**4 473**	**4 444**	**4 310**	**-3.6**
Manufacturing	..	..	7 637	7 184	7 042	-7.8
Construction	..	..	2 555	2 596	3 004	17.6
Transport and storage	..	..	1 656	1 851	1 865	12.6
Communication	..	..	632	494	478	-24.4
Public utilities	..	..	339	351	569	67.8
Wholesale and retail trade	..	..	5 520	6 005	6 286	13.9
Finance	..	..	986	1 169	1 277	29.5
Services	..	..	11 169	12 425	14 368	28.6
Public administration	..	..	2 302	2 861	3 302	43.4
Not defined	..	..	1 473	1 305	2 815	91.1
Total	**..**	**..**	**38 742**	**40 685**	**45 316**	**17.0**
Population	93 131	93 174	96 950	98 175	100 104	3.3
Urban proportion (%)	50.2	44.9	43.4	41.6	38.1	-12.1
Number of farms	806	592	534	476	438	-18.0
Farmland area (km^2)	778	607	551	562	569	3.3

Source:
Statistics Canada, National Accounts and Environment Division.

Map 8.4
Land Cover for the New Brunswick Highlands Ecoregion, 1992



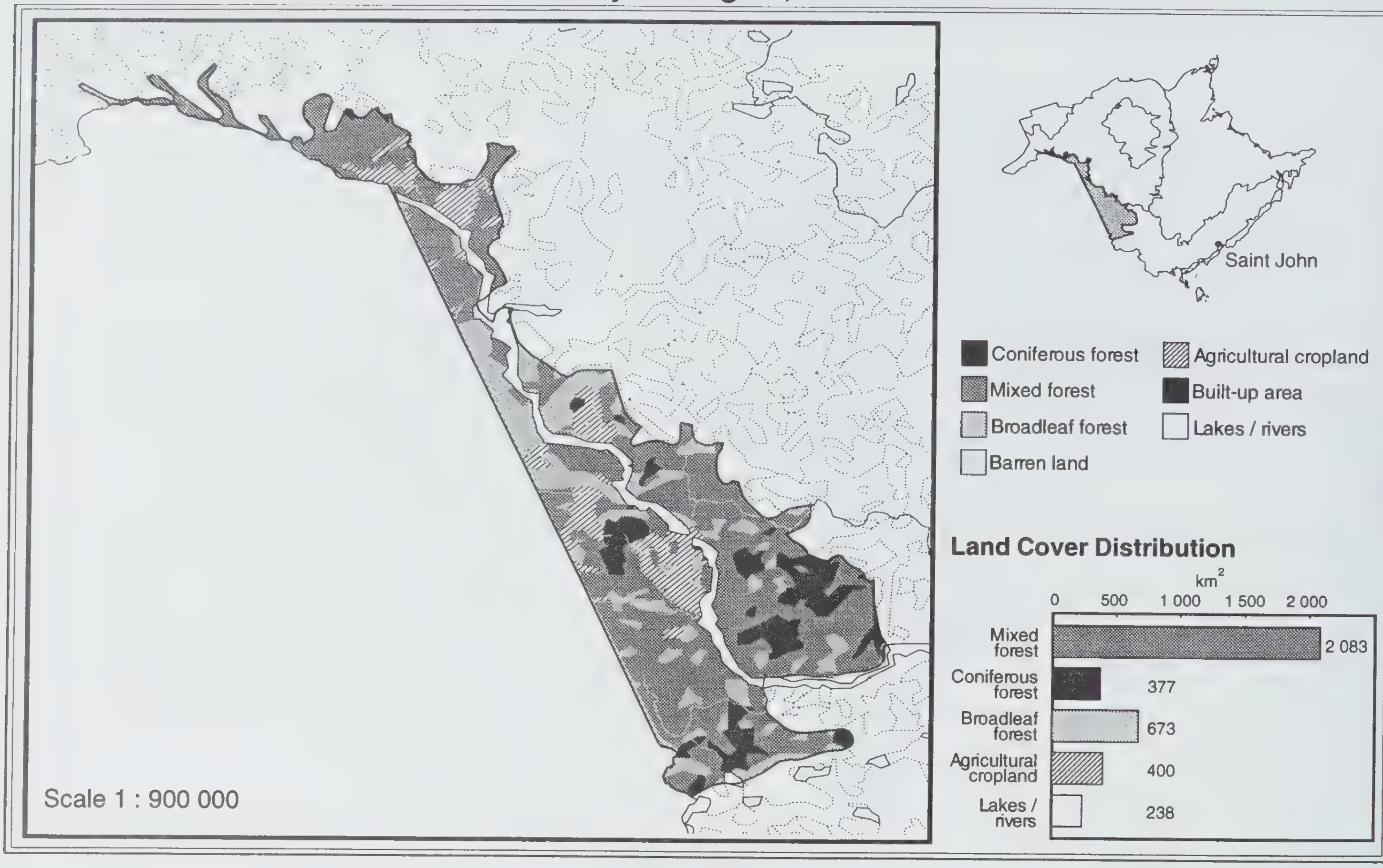
Source:
Natural Resources Canada, 1994a.

The New Brunswick Highlands Ecoregion

This unpopulated region is quite isolated from other areas of the province, and like the Northern New Brunswick Uplands it is primarily a forested area. It is characterized by steep slopes and hilly terrain. New Brunswick's highest point - Mount Carleton (817 metres) is located here.

The region occupies an area 5 066 km^2, of which 2 418 km^2 is mixed forest, 2 297 km^2 is coniferous forest and 323 km^2 is broadleaf forest. The southern-most portion of the region has a small parcel of agricultural land.

Map 8.5
Land Cover for the Saint John River Valley Ecoregion, 1992



Source:
Natural Resources Canada, 1994a.

The Saint John River Valley Ecoregion

This region of New Brunswick which is bordered by the United States on its western side, is characterized by the St. John River and its rich alluvial soils.

The region is covered primarily by forests which occupied 3 133 km^2 or 83% of the ecoregion area in 1992. Agricultural land and water cover the remainder of the region, occupying 11% and 6% of the area respectively.

The region covers an area of 3 771 km^2 and had a population of 47 879 in 1991. The rural/urban population split was 69% rural, 31% urban in 1991. Population has declined marginally in this area, from 48 665 in 1971.

The experienced labour force in the region grew by 8.6%, from 20 620 to 22 401, between 1981 and 1991.

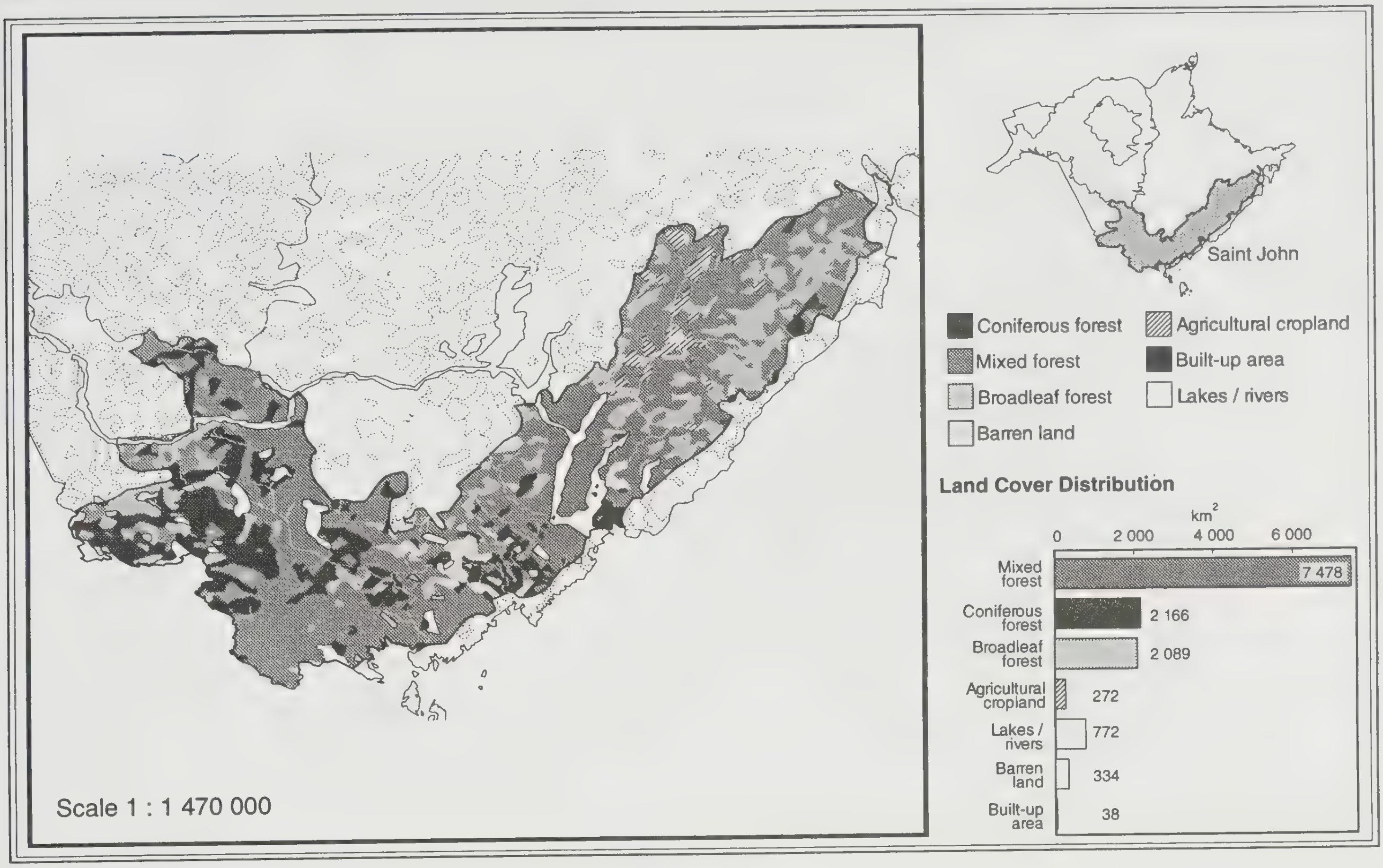
The experienced labour force in the land use intensive resource sector declined by 7.6% between 1981 and 1991.

Table 8.5
Socio-economic Profile, 1971-1991

	1971	1976	1981	1986	1991	Change 1981-91
	persons					percent
Experienced labour force						
Agriculture	..	..	2 024	2 379	2 055	1.5
Forestry	..	..	1 011	1 001	764	-24.4
Fishing and hunting	..	..	8	0	0	...
Mining	..	..	25	65	17	-32.0
Resource sector	**..**	**..**	**3 068**	**3 445**	**2 836**	**-7.6**
Manufacturing	..	..	4 240	3 964	4 146	-2.2
Construction	..	..	1 343	1 228	1 390	3.5
Transport and storage	..	..	1 125	1 124	1 171	4.1
Communication	..	..	284	275	258	-9.2
Public utilities	..	..	267	222	259	-3.0
Wholesale and retail trade	..	..	3 153	3 237	3 283	4.1
Finance	..	..	434	532	620	42.9
Services	..	..	4 823	5 462	6 149	27.5
Public administration	..	..	1 049	1 191	1 238	18.0
Not defined	..	..	834	694	1 051	26.0
Total	**..**	**..**	**20 620**	**21 374**	**22 401**	**8.6**
Population	48 665	50 018	50 587	48 617	47 879	-5.4
Urban proportion (%)	40.3	35.6	35.9	32.3	30.8	-14.1
Number of farms	1 218	1 122	950	789	637	-32.9
Farmland area (km^2)	1 327	1 290	1 215	1 101	983	-19.1

Source:
Statistics Canada, National Accounts and Environment Division.

Map 8.6
Land Cover for the Southern New Brunswick Uplands Ecoregion, 1992



Source:
Natural Resources Canada, 1994a.

The Southern New Brunswick Uplands Ecoregion

This ecoregion is located in southern New Brunswick and is characterized by a maritime climate, and rolling topography. This area occupies 13 149 km^2 or 18% of New Brunswick.

The region is covered primarily by forests which occupied 11 733 km^2 or 89% of the ecoregion in 1992. Water, barren land, agricultural cropland and built up areas occupied the remaining 11% of the region.

The rural/urban population split was 42% rural and 58% urban in 1991. Population increased significantly in this area which had a 1971 population of 126 281.

The experienced labour force in the region grew by 16.8%, from 61 714 to 72 110, between 1981 and 1991.

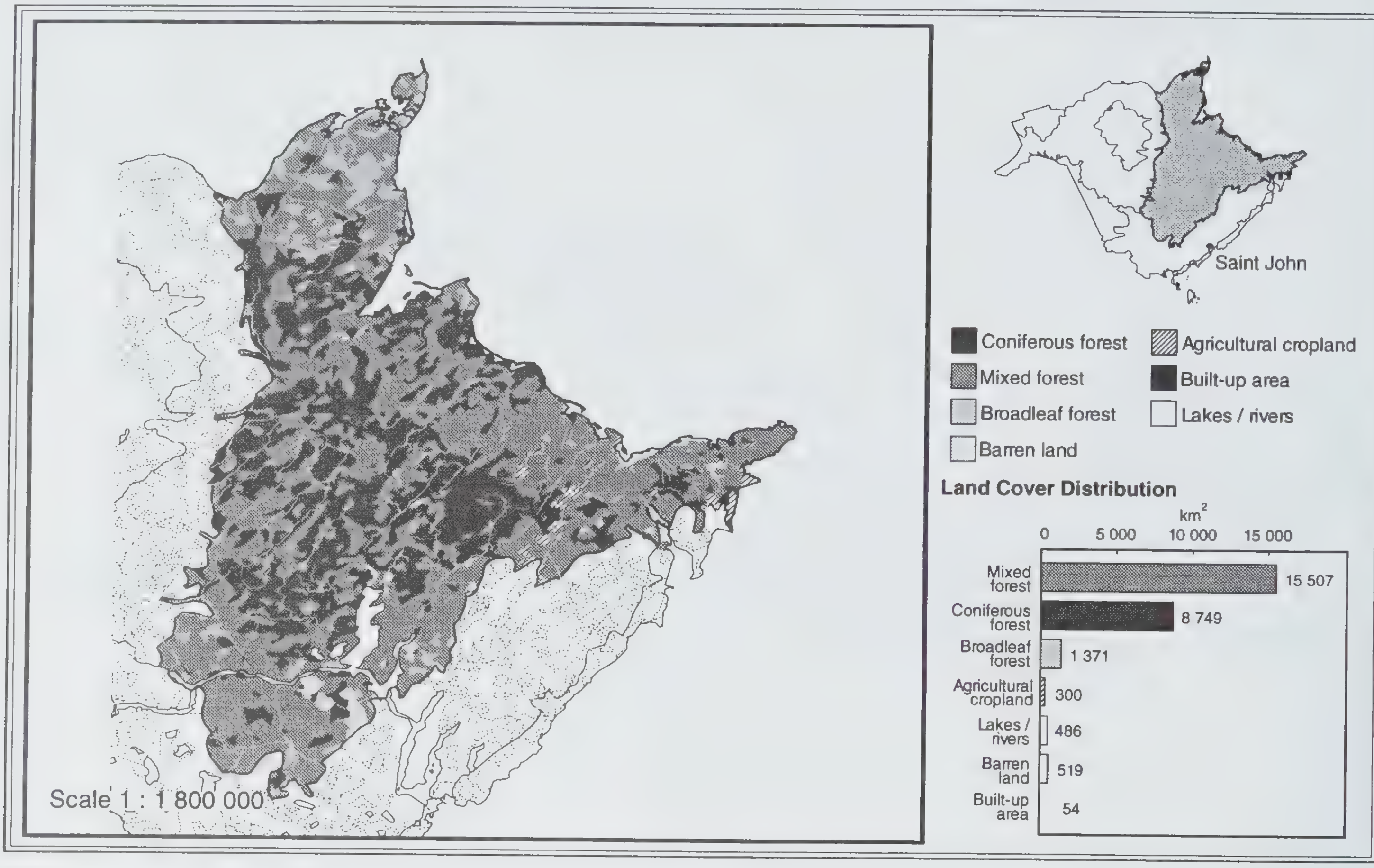
The experienced labour force in the land use intensive resource sector increased by 2.1% between 1981 and 1991. Workers with experience in forestry declined by 85%, while workers in mining and fishing/hunting increased by 258% and 89.4%, respectively.

Table 8.6
Socio-economic Profile, 1971-1991

	1971	1976	1981	1986	1991	Change 1981-91
			persons			percent
Experienced labour force						
Agriculture	..	..	1 620	1 589	1 752	8.1
Forestry	..	..	1 133	1 201	166	-85.3
Fishing and hunting	..	..	94	127	178	89.4
Mining	..	..	317	934	1 135	258.0
Resource sector	**..**	**..**	**3 164**	**3 851**	**3 231**	**2.1**
Manufacturing	..	..	9 995	9 283	10 559	5.6
Construction	..	..	4 873	4 446	4 850	-0.5
Transport and storage	..	..	3 600	3 542	3 336	-7.3
Communication	..	..	2 132	2 085	2 317	8.7
Public utilities	..	..	1 048	952	1 039	-0.9
Wholesale and retail	..	..	11 078	11 387	12 757	15.2
Finance	..	..	2 825	2 782	3 073	8.8
Services	..	..	16 982	19 917	23 285	37.1
Public administration	..	..	3 865	4 179	5 160	33.5
Not defined	..	..	2 152	1 975	2 503	16.3
Total	**..**	**..**	**61 714**	**64 399**	**72 110**	**16.8**
Population	126 281	132 988	140 107	143 534	150 766	7.6
Urban proportion (%)	69.2	61.9	61.3	59.8	57.7	-5.9
Number of farms	1 231	1 082	1 033	864	859	-16.8
Farmland area (km^2)	1 263	1 118	1 082	972	941	-13.0

Source:
Statistics Canada, National Accounts and Environment Division.

Map 8.7
Land Cover for the Maritime Lowlands Ecoregion, 1992



Source:
Natural Resources Canada, 1994a.

The Maritime Lowlands Ecoregion

This ecoregion is located in eastern New Brunswick and is characterized by a maritime climate, and relatively flat topography. The region occupies 26 986 km^2 or 36% of New Brunswick. This is New Brunswick's largest ecoregion.

This region is covered primarily by forests which occupied 25 627 km^2 or 95% of the ecoregion area in 1992. Barren land, water, agricultural cropland and built up areas occupied the remaining 5% of the region.

In 1991 the rural/urban population split was 52% rural, 48% urban. Population increased by 5.4% in this area since 1971.

The experienced labour force in the region grew by 21.4%, from 155 746 to 186 999, between 1981 and 1991.

The experienced labour force in the land use intensive resource sector increased by 0.4% between 1981 and 1991. Workers with experience in forestry declined by 15.7%, while workers in fishing/hunting increased by 28.9%. Experienced agricultural workers also increased by 15.2%.

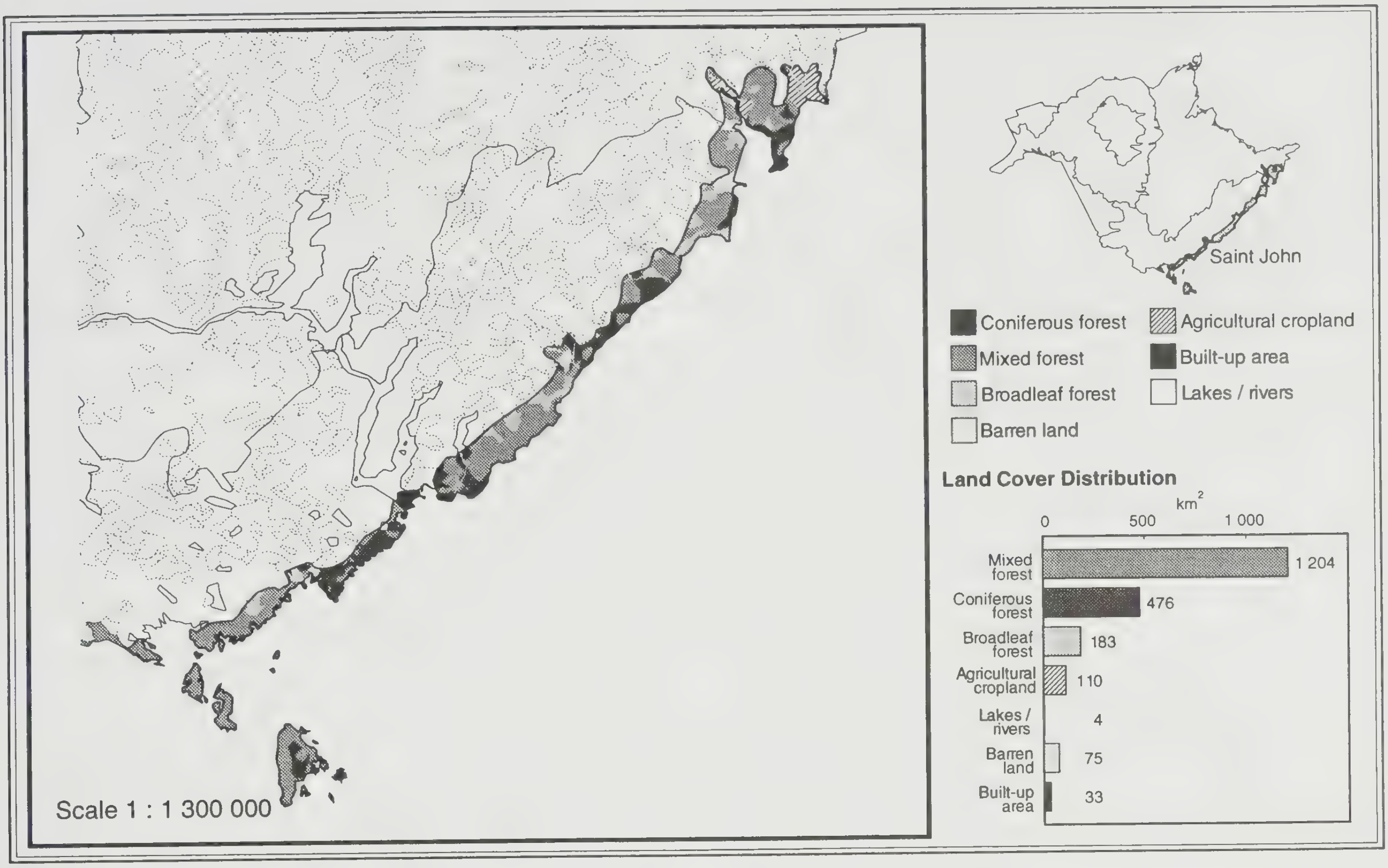
Table 8.7
Socio-economic Profile, 1971-1991

	1971	1976	1981	1986	1991	Change 1981-91
			persons			percent
Experienced labour force						
Agriculture	..	..	2 461	2 918	2 835	15.2
Forestry	..	..	4 447	4 010	3 747	-15.7
Fishing and hunting	..	..	2 306	3 187	2 972	28.9
Mining	..	..	2 696	2 191	2 409	-10.6
Resource sector	**..**	**..**	**11 910**	**12 306**	**11 963**	**0.4**
Manufacturing	..	..	22 159	21 654	21 195	-4.4
Construction	..	..	10 891	11 565	12 937	18.8
Transport and storage	..	..	8 714	9 672	8 717	0.0
Communication	..	..	2 750	2 665	2 794	1.6
Public utilities	..	..	1 672	1 958	2 530	51.3
Wholesale and retail	..	..	26 345	29 192	32 285	22.5
Finance	..	..	5 478	6 084	7 046	28.6
Services	..	..	41 491	50 291	59 411	43.2
Public administration	..	..	19 141	21 556	23 448	22.5
Not defined	..	..	5 195	5 009	6 673	28.5
Total	**..**	**..**	**155 746**	**171 952**	**188 999**	**21.4**
Population	319 803	351 776	360 745	372 033	380 280	5.4
Urban proportion (%)	55.7	53.1	50.6	49.6	48.3	-4.6
Number of farms	2 073	1 635	1 444	1 330	1 213	-16.0
Farmland area (km^2)	1 873	1 520	1 425	1 344	1 182	-17.0

Source:
Statistics Canada, National Accounts and Environment Division.

Map 8.8

Land Cover for the Fundy Coast Ecoregion, 1992



Source:
Natural Resources Canada, 1994a.

The Fundy Coast Ecoregion

This ecoregion is located in a narrow strip along the south eastern coast of New Brunswick and is characterized by a maritime climate, and relatively flat topography. The region occupies 2 085 km^2 or 3% of New Brunswick.

This region is covered primarily by forests which occupied 1 863 km^2 or 89% of the ecoregion area in 1992. Barren land, water, agricultural cropland and built-up areas occupied the remaining 11% of the region.

The 1991 population in this area was 44 871. The rural/urban population split was 48% urban, 52 % rural.

The experienced labour force in the region grew by 0.4%, from 21 195 to 21 276, between 1981 and 1991.

The experienced labour force in the land use intensive resource sector increased by 30.1% between 1981 and 1991. Workers with experience in forestry declined by 19.4%, while workers in fishing/hunting increased by 6.5%.

Table 8.8

Socio-economic Profile, 1971-1991

	1971	1976	1981	1986	1991	Change 1981-91
	persons					percent
Experienced labour force						
Agriculture	..	..	134	98	445	232.1
Forestry	..	..	180	117	145	-19.4
Fishing and hunting	..	..	775	865	825	6.5
Mining	..	..	20	30	28	40.0
Resource sector	**..**	**..**	**1 109**	**1 110**	**1 443**	**30.1**
Manufacturing	..	..	4 125	3 582	3 907	-5.3
Construction	..	..	1 642	1 167	1 371	-16.5
Transport and storage	..	..	1 379	1 209	1 100	-20.2
Communication	..	..	548	521	510	-6.9
Public utilities	..	..	429	335	361	-15.9
Wholesale and retail	..	..	3 077	3 100	2 809	-8.7
Finance	..	..	787	771	586	-25.5
Services	..	..	5 676	6 580	6 595	16.2
Public administration	..	..	1 764	1 744	1 862	5.6
Not defined	..	..	659	715	732	11.1
Total	**..**	**..**	**21 195**	**20 834**	**21 276**	**0.4**
Population	46 677	49 293	48 014	47 083	44 871	-6.5
Urban proportion (%)	62.7	52.3	51.1	49.6	48.3	-5.5
Number of farms	157	120	102	95	105	2.9
Farmland area (km^2)	178	133	106	110	81	-23.9

Source:
Statistics Canada, National Accounts and Environment Division.

Land use profiles from Statistics Canada census information

New Brunswick's land is used for many different purposes. Every square metre of land has a host of natural processes taking place upon it. Examples include, water absorption or evaporation, vegetation growth or decay, or even seasonal heat loss or gain. Recently, human activities have begun to use greater and greater amounts of land. These activities range from low intensity uses like a recreational hike through an area, to more intense activities such as the cultivation of an agricultural field or the clear cutting of a forest.

Economic activities that use land have a lasting effect on the landscape. The economic infrastructure we see today originates upon land that once supported only natural habitats. Examples of natural habitat conversion include the construction and maintenance of paved roadways through forested areas as well as the development of towns and cities along these transportation corridors. Most changes in the economy have an immediate land use change implication. An intensification of a particular land use activity requires more resource inputs and tends to displace competing activities, particularly if the competing activities are natural processes. This is because natural processes operate independently of the economy and are seldom given a price and are often given only aesthetic value. For example, opening up new land for agricultural production modifies existing natural habitat and requires that nutrients and energy be imported to offset those consumed by the crop which is harvested. The opposite can also be true when a decline in an economic activity allows competing activities to re-build and intensify. One example of this set of circumstances would be the re-population of a stream with salmon after a newly regenerated forest takes root in a logged watershed.

Information from Statistics Canada's censuses is ideally suited for analysis of broad socio-economic trends which affect land. The census data do not provide sufficient detail to address issues such as a change in micro-habitat, but they do provide important insight into the impact of larger scale human activities on the environment.

Population

The intensity of many economic land use activities is related to the distribution of human populations. In 1991, the province of New Brunswick had a population of 723 900 people, with an average density of 9.7 people per km^2 (Table 8.9). Provincial population grew by 14.1%, between 1971 and 1991.

In 1991, the Maritime Lowlands ecoregion had the highest population of any ecoregion in New Brunswick, with more than 380 thousand inhabitants. The major urban centres of Fredericton, Moncton and Miramichi are located within this ecoregion. The next most populous region is the Southern New Brunswick Uplands. This region was home to more than 150 thousand individuals in 1991. The remaining three populated ecoregions the Northern New Brunswick Uplands, the Saint John River Valley and the Fundy Coast had 100 thousand, 48 thousand and 45 thousand inhabitants respectively. There are two ecoregions with no recorded permanent residents in recent census years, The Appalachian ecoregion and the New Brunswick Highlands ecoregion.

The population density figures in Table 8.9 indicate the distribution of people relative to the supporting land base. The Fundy Coast ecoregion is the most densely populated, with densities ranging from 22 to 24 people per km^2, between 1971 and 1991. The Maritime Lowlands and Saint John River Valley regions were the second and third most densely populated regions in 1991, with an average of 14.1 and 12.7 people per km^2 respectively. Trends that indicate increasing densities indicate areas where land use competition is likely on the rise as well. This is particularly true in the Maritime Lowlands where the urban centres of Fredericton and Moncton have been expanding over the past 20 years.

Table 8.10 examines the urban/rural composition of New Brunswick's population by ecological region. Unlike most other provinces and territories in Canada, the general trend in New Brunswick is towards an increasingly rural population. Rural population has increased by 38.5%, while urban population has declined by 4.4% for the province as a whole. In New Brunswick, the rural non-farm population is increasing while the farm population appears to be declining. Most of the rural population increase is occurring in the

Table 8.9
Population by Ecoregion, 1971-1991

Ecoregion	Ecoregion area	Population					Population change	Average population density				
		1971	1976	1981	1986	1991	1971-1991	1971	1976	1981	1986	1991
	km^2	persons					percent	persons per km^2				
Appalachians	2 392	-	-	-	-	-	-	-	-	-	-	-
Northern New Brunswick Uplands	21 049	93 131	93 174	96 950	98 175	100 104	7.5	4.4	4.4	4.6	4.7	4.8
New Brunswick Highlands	5 066	-	-	-	-	-	-	-	-	-	-	-
Saint John River Valley	3 771	48 665	50 018	50 587	48 617	47 879	-1.6	12.9	13.3	13.4	12.9	12.7
Southern New Brunswick Uplands	13 149	126 281	132 988	140 107	143 534	150 766	19.4	9.6	10.1	10.7	10.9	11.5
Maritime Lowlands	26 986	319 803	351 776	360 745	372 033	380 280	18.9	11.8	13.0	13.4	13.8	14.1
Fundy Coast	2 085	46 677	49 293	48 014	47 083	44 871	-3.9	22.4	23.6	23.0	22.6	21.5
Total	**74 498**	**634 557**	**677 249**	**696 403**	**709 442**	**723 900**	**14.1**	**8.5**	**9.1**	**9.3**	**9.5**	**9.7**

Sources:
Statistics Canada, National Accounts and Environment Division and Demography Division.

Table 8.10

Rural and Urban Population by Ecoregion, 1971-1991

Ecoregion	Ecoregion area	Rural population 1971	1976	1981	1986	1991	Change 1971-1991	Urban population 1971	1976	1981	1986	1991	Change 1971-1991
	km^2	persons					percent	persons					percent
Appalachians	2 392	-	-	-	-	-	-	-	-	-	-	-	-
Northern New Brunswick Uplands	21 049	46 374	51 346	54 885	57 315	61 922	33.5	46 757	41 828	42 065	40 860	38 182	-18.3
New Brunswick Highlands	5 066	-	-	-	-	-	-	-	-	-	-	-	-
Saint John River Valley	3 771	29 073	32 215	32 438	32 901	33 132	14.0	19 592	17 803	18 149	15 716	14 747	-24.7
Southern New Brunswick Uplands	13 149	38 876	50 660	54 220	57 738	63 812	64.1	87 405	82 328	85 887	85 796	86 954	-0.5
Maritime Lowlands	26 986	141 677	165 115	178 168	187 481	196 625	38.8	178 126	186 661	182 577	184 552	183 655	3.1
Fundy Coast	2 085	17 410	23 495	23 472	23 704	23 195	33.2	29 267	25 798	24 542	23 379	21 676	-25.9
Total	**74 498**	**273 410**	**322 831**	**343 183**	**359 139**	**378 686**	**38.5**	**361 147**	**354 418**	**353 220**	**350 303**	**345 214**	**-4.4**

Note:
An urban area is an area which has attained a population of at least 1 000 and a population density of at least 400 per square kilometre, at the previous census. Rural areas include all areas that do not meet the urban definition.
Sources:
Statistics Canada, National Accounts and Environment Division and Demography Division.

Table 8.11

Number of Farms and Average Farm Size by Ecoregion, 1971-1991

Ecoregion	Ecoregion area	Number of farms 1971	1976	1981	1986	1991	Change 1971-1991	Average farm size 1971	1976	1981	1986	1991	Change in size 1971-1991
	km^2	number					percent	hectares per farm					percent
Appalachians	2 392	-	-	-	-	-		-	-	-	-	-	-
Northern New Brunswick Uplands	21 049	806	592	534	476	438	-45.7	96.6	102.6	103.2	118.0	129.9	34.6
New Brunswick Highlands	5 066	-	-	-	-	-		-	-	-	-	-	-
Saint John River Valley	3 771	1 218	1 122	950	789	637	-47.7	109.0	114.9	127.9	139.5	154.3	41.6
Southern New Brunswick Uplands	13 149	1 231	1 082	1 033	864	859	-30.2	102.6	103.3	104.7	112.5	109.6	6.8
Maritime Lowlands	26 986	2 073	1 635	1 444	1 330	1 213	-41.5	90.3	93.0	98.7	101.0	97.5	7.9
Fundy Coast	2 085	157	120	102	95	105	-33.1	113.6	110.5	103.8	116.2	76.8	-32.4
Total	**74 498**	**5 485**	**4 551**	**4 063**	**3 554**	**3 252**	**-40.7**	**98.8**	**102.6**	**107.8**	**115.0**	**115.5**	**16.9**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

rural fringes of larger urban centres and in a selection of small rural centres.

Individual ecoregions that are showing large urban declines are the Fundy Coast and the Saint John River Valley with 25.9% and 24.7% declines, respectively.

These statistics indicate that land use competition associated with increases in urban core populations are not as pronounced in New Brunswick as they are elsewhere in Canada. For the most part New Brunswick's ecoregions, with perhaps the exception of the Maritime Lowlands, show stable or declining urban populations.

Agriculture

Agriculture is a major user of quality land in New Brunswick. All of the most fertile lands in the province are now fully utilized by agriculture.

New Brunswick's agricultural industry has been undergoing significant changes over the last 20 years. Most of these changes have land use implications. Table 8.11 indicates that the total number of farms has declined significantly. The number of farms shrank from 5 485 in 1971, to 3 252 in 1991, representing a 40.7% decline. At the same time average farm sizes have been increasing going from 98.8 hectares in 1971, to 115.5 hectares in 1991, for a 16.9% increase in average size.

The land use implications of an increasing farm size are clear. Fewer and fewer people are operating more and more land, indicating that land use decisions are now being made at a larger scale relative to a larger farm size. This increasing size trend also signals the decline of the traditional individual family farm. In fact, the number of individual family farms dropped from 93% of New Brunswick farms in 1976, to an all time low of 68% of farms in 1991.

The area of farmland in operation in New Brunswick declined in all ecoregions (Table 8.12). The relative declines ranged from 25% in the Southern New Brunswick Uplands to 55% in the Fundy Coast. The region with the largest absolute decline in area was the Maritime Lowlands, losing 691 km^2 or approximately one third of its farmland area since 1971. Declining farmland areas do not imply that all of the land that was farmland is now essentially abandoned, but rather that much of it may have moved to other main uses such as residential, commercial, recreational, or even to newly forested land.

Table 8.12

Farmland by Ecoregion, 1971-1991

Ecoregion	Ecoregion area	Farmland area 1971	1976	1981	1986	1991	Change 1971-1991	Proportion of ecoregion in farmland 1971	1976	1981	1986	1991
	km2						percent					
Appalachians	2 392	-	-	-	-	-	-	-	-	-	-	-
Northern New Brunswick Uplands	21 049	778	607	551	562	569	-26.9	4	2.89	2.62	2.67	2.70
New Brunswick Highlands	5 066	-	-	-	-	-	-	-	-	-	-	-
Saint John River Valley	3 771	1 327	1 290	1 215	1 101	983	-26.0	35	34.20	32.23	29.20	26.07
Southern New Brunswick Uplands	13 149	1 263	1 118	1 082	972	941	-25.4	10	8.50	8.23	7.39	7.16
Maritime Lowlands	26 986	1 873	1 520	1 425	1 344	1 182	-36.9	7	5.63	5.28	4.98	4.38
Fundy Coast	2 085	178	133	106	110	81	-54.8	9	6.36	5.08	5.29	3.87
Total	**74 498**	**5 419**	**4 668**	**4 379**	**4 089**	**3 756**	**-30.7**	**7**	**6.27**	**5.88**	**5.49**	**5.04**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 8.13

Cropland by Ecoregion, 1971-1991

Ecoregion	Ecoregion area	Cropland area 1971	1976	1981	1986	1991	Change 1971-1991	Proportion of farmland in cropland 1971	1976	1981	1986	1991	Change 1971-1991
	km2						percent						
Appalachians	2 392	-	-	-	-	-	-	-	-	-	-	-	-
Northern New Brunswick Uplands	21 049	219	205	195	212	197	-10.4	28.2	33.7	35.5	37.6	34.5	22.6
New Brunswick Highlands	5 066	-	-	-	-	-	-	-	-	-	-	-	-
Saint John River Valley	3 771	484	522	492	480	457	-5.7	36.5	40.5	40.5	43.6	46.5	27.4
Southern New Brunswick Uplands	13 149	226	246	241	233	234	3.3	17.9	22.0	22.3	24.0	24.8	38.6
Maritime Lowlands	26 986	340	365	353	340	314	-7.5	18.1	24.0	24.8	25.3	26.6	46.6
Fundy Coast	2 085	35	32	24	30	21	-39.8	19.4	24.2	22.3	27.4	25.8	33.1
Total	**74 498**	**1 304**	**1 371**	**1 305**	**1 295**	**1 222**	**-6.3**	**24.1**	**29.4**	**29.8**	**31.7**	**32.5**	**35.2**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

One useful land use intensity measure that can be derived from census data is the proportion of an ecoregion's area that is used for farmland. This measure combined with other land use information (industrial, residential, commercial) would provide an indication of the degree to which human activity has altered natural ecosystems and potentially influenced biodiversity in an area.

Table 8.12 summarizes findings for New Brunswick and its ecoregions. The province has a relatively low proportion of its land in agriculture. In 1991 only 5% of land in New Brunswick was used for agriculture, in contrast, Saskatchewan used 47% of its land for agriculture. The divergence in these figures is due primarily to the supply of arable land available in each province. New Brunswick has a very limited supply of quality agricultural land which can be seen in Table 8.12.

From an ecoregion perspective, of the five ecoregions that have agriculture, four have less than 10% of their area in agriculture. The exception is the Saint John River Valley which had 35.2% farmland in 1971, declining to 26.1% by 1991. Most of New Brunswick's highest quality agricultural land is located in this region.

In general, this decline in farmland proportions can be seen as beneficial from an environmental perspective. The reduced extent of active agriculture allows competing natural processes such as the growth of wildlife populations to expand. Declines in farmland area also indicate that pressure on marginally productive farmland which cannot sustain long term production is likely declining.

Table 8.13 presents New Brunswick's cropland distribution by ecoregion. The distribution of cropland within an area, provides an indicator of how intensively a particular ecoregion's farmland is being utilized. Cropland tends to be the most highly cultivated land, demanding more tillage, fertilizer and pesticides than other types of farmland.

The total area of cropland declined by 6.3%. This is a modest decline, relative to the more dramatic 30.7% decrease in farmland area. Table 8.13 presents the area of cropland and the proportion of farmland devoted to crops. A greater proportion of farmland is being utilized to produce crops. Over the longer term there is a clear indication that land use intensity on farmland in each ecoregion is on the rise.

Trends in cropping practice indicate changing levels of environmental stress, and help to answer questions about the long term sustainability of agriculture and the soils which support it. Table 8.14 presents trends in the area of wide-row monoculture for the province of New Brunswick. Wide-row monoculture is the continual planting of wide-row crops on a year after year basis. This practice is often damaging

and is often carried out in an effort to maintain cash flow on farms.

From an ecological perspective, the most stable biotic communities are very complex with countless species interacting to form a diverse community network. The tropical rain forest is perhaps the most stable ecological community, deriving its stability from a multitude of checks and balances that serve to suppress the domination of any particular species, while at the same time preventing the extinction of other species. In contrast, monoculture cropping systems are inherently unstable; they are more susceptible to outbreaks of insects, disease, weeds and micro-nutrient imbalances. Despite these high ecological costs, monoculture cropping systems are the most productive. They create their own economies of scale and use specialisation to increase production levels. Monoculture levels can be measured from census data by looking at the land use information reported on census questionnaires.

Table 8.14

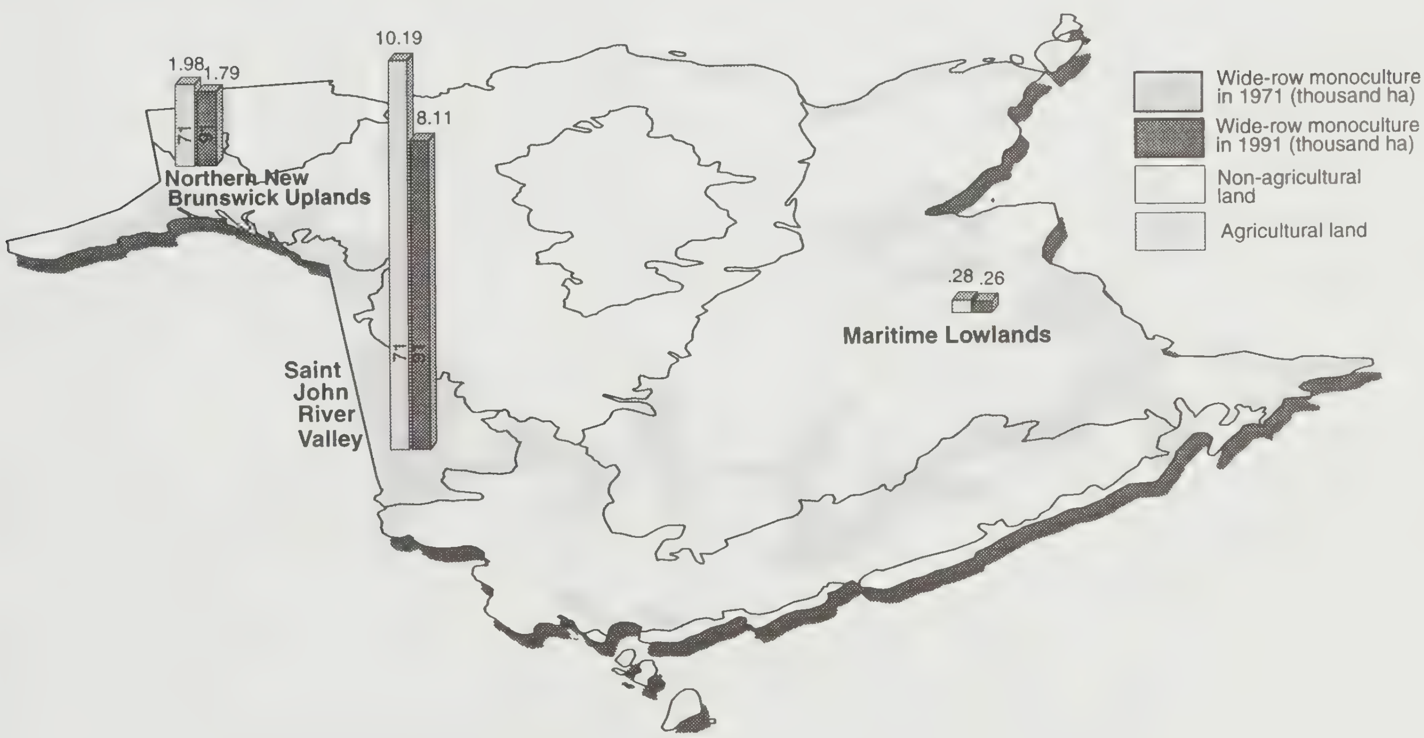
Cropland in Wide-row Monoculture Crops by Ecoregion, 1971-1991

Ecoregion	Ecoregion area	Wide-row monoculture cropland area					Change	Proportion of total cropland in wide-row monoculture				
		1971	1976	1981	1986	1991	1971-1991	1971	1976	1981	1986	1991
	km^2	hectares					percent					
Appalachians	2 392	-	-	-	-	-	-	-	-	-	-	-
Northern New Brunswick Uplands	21 049	1 979	2 479	2 212	2 258	1 793	-9.4	9.0	12.1	11.3	10.7	9.1
New Brunswick Highlands	5 066	-	-	-	-	-	-	-	-	-	-	-
Saint John River Valley	3 771	10 193	11 287	7 922	8 249	8 107	-20.5	21.0	21.6	16.1	17.2	17.7
Southern New Brunswick Uplands	13 149	-	-	-	-	-	-	-	-	-	-	-
Maritime Lowlands	26 986	276	270	892	249	255	-7.6	0.8	0.7	2.5	0.7	0.8
Fundy Coast	2 085	-	-	-	-	-	-	-	-	-	-	-
Total	**74 498**	**12 448**	**14 036**	**11 026**	**10 756**	**10 154**	**-18.4**	**9.5**	**10.2**	**8.4**	**8.3**	**8.3**

Note:
Wide-row monoculture is defined as the planting of wide-row crops, on a continual year after year basis, on the same parcel of land.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 8.9

Wide-row Monoculture by Ecoregion, 1971 and 1991



Note:
Wide-row monoculture is defined as the planting of wide-row crops, on a continual year after year basis, on the same parcel of land.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Wide-row monoculture demands high levels of agricultural inputs. Pesticide expenses per hectare on wide-row monoculture farms are 5 times those on other farms, while fertilizer expenses are more than 4 times higher. Wide-row monocultures have an erosion rate 2-3 times that of a grain crop.

The practice of wide row monoculture is most common in the Saint John River Valley (Map 8.9).

In New Brunswick wide-row monoculture trends are in decline after reaching a maximum extent of more than 14 thousand hectares in 1976. From 1971 to 1991 wide-row monoculture areas have declined by more than 18%. This is indeed a positive environmental trend and indicates that farmers in New Brunswick are now employing their land in less stressful cropping systems, allowing the soil some respite from continual cash crop production.

Table 8.15 presents information on cropland under crop rotation by ecoregion. As the table indicates, most cropland in New Brunswick falls into this general category indicating a healthier mix of crops.

Other relevant agricultural land use statistics derived from census data relate to farm chemical inputs which are applied to farmland on a large scale. Both pesticides and fertilizers which have high potential environmental impact, are included on this list.

Agricultural pesticides are applied to control insects, weeds and crop diseases in an effort to maintain crop quantity and quality. Table 8.16 shows expenditures on pesticide being applied on improved farmland. Pesticide expense data provide an indication of the amount of pesticide entering the environment. Many factors influence the environmental impacts of pesticides. These include the time of application, rainfall, stability of the pesticide, method of application, and many others. The application rate for pesticides applied on farmland in New Brunswick increased by more than 93% between 1970 and 1990 (Table 8.16). The ecoregion with the highest application rate is again the Saint John River Valley where wide-row crop production is also highest.

On a national basis, New Brunswick pesticide application rates in dollar terms are quite high. New Brunswick's 1990 rate of 49 dollars per hectare is triple the national average of 16 dollars.

The application of commercial fertilizers can also pose some unique impacts on the environment. Ideally, the majority of agricultural fertilizers are consumed by crops shortly after application. However, residual fertilizer nutrients can be lost to the atmosphere, absorbed by wild plant species or be released from the soil into both surface and ground-

Table 8.15

Cropland in Crop Rotation by Ecoregion, 1971-1991

Ecoregion	Ecoregion area	Rotational cropland area					Change	Proportion of total cropland in rotational crops				
		1971	1976	1981	1986	1991	1971-1991	1971	1976	1981	1986	1991
	km^2	hectares					percent					
Appalachians	2 392	-	-	-	-	-	-	-	-	-	-	-
Northern New Brunswick Uplands	21 049	14 499	15 359	13 109	13 151	13 207	-8.9	66.1	75.0	67.1	62.2	67.2
New Brunswick Highlands	5 066	-	-	-	-	-	-	-	-	-	-	-
Saint John River Valley	3 771	20 150	32 619	32 705	33 077	30 718	52.4	41.6	62.5	66.4	68.9	67.2
Southern New Brunswick Uplands	13 149	16 517	23 038	21 202	20 523	20 980	27.0	73.1	93.5	88.0	88.0	89.8
Maritime Lowlands	26 986	28 036	33 387	30 614	28 946	24 836	-11.4	82.5	91.4	86.8	85.3	79.0
Fundy Coast	2 085	3 086	2 832	1 977	1 950	1 374	-55.5	89.2	88.1	83.6	64.4	66.1
Total	**74 498**	**82 287**	**107 234**	**99 606**	**97 646**	**91 114**	**10.7**	**63.1**	**78.2**	**76.3**	**75.4**	**74.5**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

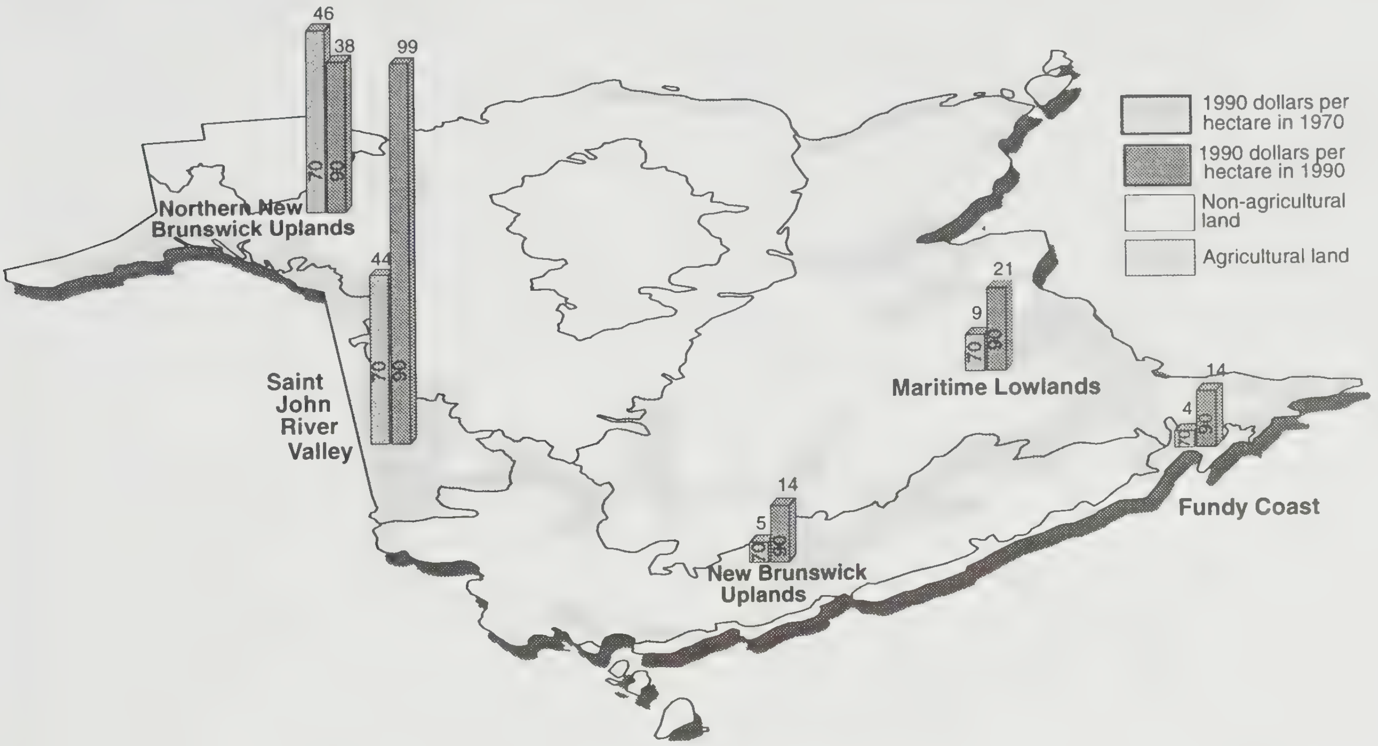
Table 8.16

Agricultural Pesticide Expenditures by Ecoregion, 1970-1990

Ecoregion	Ecoregion area	Agricultural pesticide expenditure					Change	Application rate					Change
		1970	1975	1980	1985	1990	1970-1990	1970	1975	1980	1985	1990	1970-1990
	km^2	thousand 1991 dollars					percent	1991 dollars per hectare of improved land					percent
Appalachians	2 392	-	..	-	-	-	-	-	..	-	-	-	-
Northern New Brunswick Uplands	21 049	1 292	..	755	1 035	832	-35.6	46	..	31	43	38	-17.5
New Brunswick Highlands	5 066	-	..	-	-	-	-	-	..	-	-	-	-
Saint John River Valley	3 771	2 518	..	3 906	4 235	5 010	99.0	44	..	67	78	99	125.1
Southern New Brunswick Uplands	13 149	158	..	165	256	430	171.1	5	..	5	8	14	193.1
Maritime Lowlands	26 986	451	..	543	746	841	86.2	9	..	11	17	21	133.3
Fundy Coast	2 085	24	..	25	28	37	51.8	4	..	6	6	14	272.8
Total	**74 498**	**4 444**	**..**	**5 394**	**6 300**	**7 149**	**60.9**	**25**	**..**	**31**	**40**	**49**	**93.2**

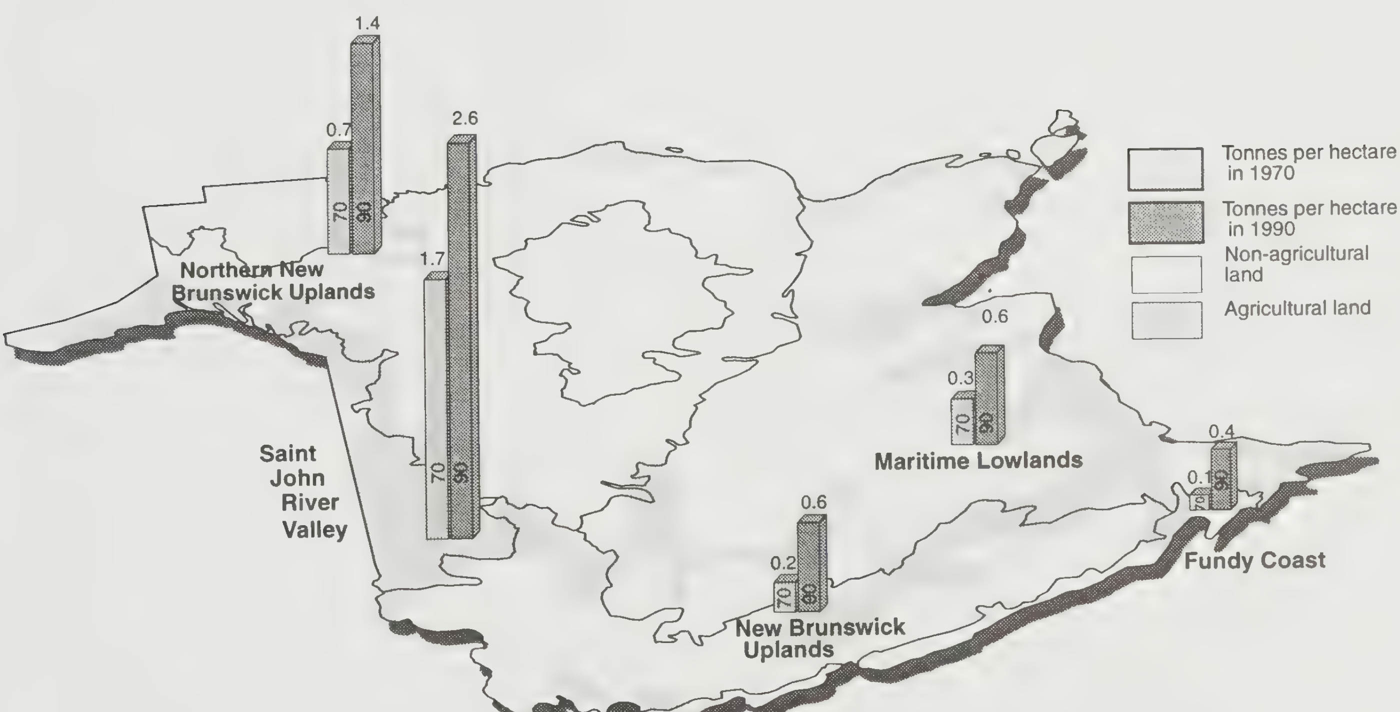
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 8.10
Value of Agricultural Pesticides Applied, by Ecoregion, 1970 and 1990



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Map 8.11
Fertilizer Use by Ecoregion, 1970 and 1990



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 8.17
Agricultural Fertilizer Application by Ecoregion, 1970-1990

Ecoregion	Ecoregion area	Commercial fertilizer 1970	1975	1980	1985	1990	Change 1970-1990	Application rate 1970	1975	1980	1985	1990	Change 1970-1990
	km^2	tonnes					percent	tonnes per hectare of improved land					percent
Appalachians	2 392	-	..	-	-	-	-	-	..	-	-	-	-
Northern New Brunswick Uplands	21 049	6 194	..	7 099	8 488	6 001	-3.10	0.74	..	1.01	1.76	1.40	89.7
New Brunswick Highlands	5 066	-	..	-	-	-	-	-	..	-	-	-	-
Saint John River Valley	3 771	23 046	..	32 296	27 091	24 487	6.26	1.68	..	2.29	2.41	2.57	53.0
Southern New Brunswick Uplands	13 149	2 986	..	4 227	4 383	5 543	85.60	0.23	..	0.32	0.45	0.55	144.8
Maritime Lowlands	26 986	5 774	..	8 569	7 419	7 207	24.83	0.28	..	0.47	0.59	0.57	104.8
Fundy Coast	2 085	316	..	352	563	310	-1.90	0.09	..	0.15	0.31	0.39	322.2
Total	**74 498**	**38 316**	**..**	**52 543**	**47 944**	**43 549**	**13.66**	**0.64**	**..**	**0.96**	**1.19**	**1.17**	**81.5**

Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

water supplies. The degree to which fertilizers impact the environment is largely dependent on local conditions at the time of application.

Table 8.17 presents the tonnes of fertilizer applied in each ecoregion and the average rate at which it was applied. The Saint John River Valley ecoregion uses more than half of the province's agricultural fertilizer largely because of the crop types that are grown there. The application rates in this region are also much higher than they are in the other regions of New Brunswick.

Maps 8.10 and 8.11 provide graphic evidence of the differences in both pesticide and fertilizer use for the ecoregions of New Brunswick. The magnitude of the differences in application rates is quite apparent from the varying heights of the bars presented.

Conclusion

Results from the Pilot Land Accounts for New Brunswick illustrate that the estimation techniques learned and applied in New Brunswick will have value when applied elsewhere in Canada. The large national data sets that were selected for this study were able to provide relevant land accounting information for small sub-provincial areas.

This study found that population pressures and associated land use competition that have persisted around many Canadian cities were generally absent throughout most of New Brunswick. In fact, trends indicate that more and more people are choosing to live at lower densities outside cities, in a rural setting.

From an agricultural land use perspective, the area of agricultural land operated in New Brunswick has declined, indicating that land use competition between agriculture and other uses has also declined over the last 20 years. Other findings indicate that land use intensity on remaining farmland increased because a greater and greater share of farmland was being cropped.

Environmentally stressful wide-row monoculture trends appear to be in decline, while pesticide and fertilizer application rates both increased over the 20 year study period.

The land cover picture emphasizes New Brunswick's status as a forested province. More than 95% of the province is forested. Limitations to the land cover analysis come largely from the fact that historical land cover data have not yet been utilized, making it difficult to address the important environmental change questions that are associated with changing land cover types. Future land accounting initiatives will hopefully overcome this shortfall.

References

Government of Canada, 1991, *The State of Canada's Environment*, Ottawa.

Natural Resources Canada, 1994a, *Canada Vegetation Cover-Digital Satellite Image*, Ottawa.

______, 1994b, *Vegetation Cover for Canada Map*, Ottawa.

Statistics Canada, 1994, *Human Activity and the Environment 1994*, Catalogue No. 11-509E, Ottawa.

______, 1995, *National Balance Sheet Accounts*, Catalogue No. 13-214, Ottawa.

World Resources Institute, 1990, *World Resources 1990-91*, New York.

9 Valuation of Canada's Agricultural Land

by Julie McAuley

Introduction

Quality agricultural land is a scarce resource in Canada. Even though 100 million hectares out of a land area of 922 million hectares are capable of supporting any kind of agricultural production, only 45 million hectares are capable of supporting field crops, and only 4 million hectares, or 0.5% of the land area (about the size of Prince Edward Island), are considered prime agricultural land. The conservation of land for the future requires that today's land valuation take into account all the costs associated with its use.

The purpose of this paper is to outline an alternative method for valuing Canada's agricultural land. The first part examines current methods of agricultural land valuation, while the remainder outlines a new technique in which the value of land is derived from agricultural inputs and outputs. The case study deals with the province of New Brunswick and offers a first estimation based on available data.

Land in the national accounts

In the latest international guidelines on national accounting,[1] land is defined as the ground itself, with the soil and associated surface water, to the exclusion of everything else that may be related to it (buildings, crops, trees, subsoil assets, etc.). It is classified as a tangible non-produced asset and divided into broad categories, on the basis of utilization: (1) land underlying buildings and structures; (2) land under cultivation (covered by crops or timber); (3) recreational land (national parks for instance); and (4) other land (undeveloped or unexploited).

Since the SNA is a framework designed for the purposes of economic analysis, it focuses mainly on economic production and economic assets. Natural assets (i.e., land, subsoil assets, timber, water resources) are called tangible non-produced assets and are included in the balance sheet accounts when they are subject to effective ownership and are capable of bringing economic benefits to their owners. In other words, only resources which can be put to an economic use are deemed to contribute to national wealth. Environmental assets on which no property can be established, such as air or the high seas, are ignored.

Presently, in the Canadian System of National Accounts (CSNA), the only tangible non-produced asset appearing on the national balance sheet is "commercial" land, subdivided into residential, non-residential and agricultural land. The value of agricultural land is derived from farm real estate values reported to the quinquennial *Census of Agriculture*, which are then split between land and buildings. Estimates for intercensal years are based on real estate transactions of farm holdings. Public land is ignored.

In accordance with the recommendations of the 1993 SNA, Statistics Canada will incorporate natural resources in the national balance sheet, beginning with the historical revision of 1997. In the case of land, the task that lies ahead is twofold. First, there is a need to establish a value for all land presently excluded, which is mostly publicly-owned and undeveloped. Secondly, existing valuation methods must be re-examined, especially for agricultural land.

The problem is that the market value of farm real estate reported to the Census tends to reflect the potential for alternative use - usually for urban development - rather than the intrinsic value of the farmland. A valuation methodology is needed to capture this intrinsic value.

Statistics Canada's Land Account

Statistics Canada will develop a land account that will systematically classify land, by type of vegetation cover and by use. All land will eventually be valued in the land account according to its use. Statistics Canada is debating whether these values will replace the existing ones in the National Balance Sheet. A separate set of estimates will also provide values according to potential (refer to Chapter 7).

Agricultural land in Canada

The geographic distribution and value of agricultural land is far from uniform. Land uniquely suited for growing certain crops like corn, fruit, tobacco, and most vegetables (approximately 4.4 million hectares) is found mainly in southern Ontario, the Annapolis Valley in Nova Scotia and the Lower Fraser Valley in British Columbia. According to the Canada Land Inventory, 71% of the country's good land (Classes 1-3) is located in the Prairie Provinces. Roughly 87% of Canada's very best farmland (Class 1) is located within 160 kilometres of the 23 largest cities, and 57%, within 80 kilometres of these centres (Statistics Canada, 1994a; Environment Canada, 1980).

Historical statistics on the number of farms and use of farmland are presented in Table 9.1. The total area devoted to farmland has been fairly constant since the 1940s. Less farmland is being left idle, however, as the share of improved farmland has been on the increase. The number of farms has decreased from a peak of 733 thousand in 1941

1. United Nations *et. al.*, 1993; para. 10.121 (hereafter abbreviated as 1993 SNA).

Table 9.1
Farms and Farmland, 1901-1991

Year	Improved farmland: Cropland	Improved farmland: Improved pasture	Improved farmland: Summer fallow	Improved farmland: Other land[1]	Unimproved farmland	Total farmland	Number of farms	Average farm size
	million hectares						thousands	hectares per farm
1901	8.1	–	--	4.1	13.5	25.7	511.1	50.3
1911	14.4	–	1.0	4.3	24.4	44.1	682.8	64.6
1921	20.2	3.1	4.8	0.5	28.4	57.0	711.1	80.2
1931	23.6	3.2	6.8	1.1	31.3	66.0	728.6	90.6
1941	22.8	3.4	9.5	1.4	33.1	70.2	732.9	95.8
1951	25.2	4.0	8.9	1.1	31.2	70.4	623.1	113.0
1961	25.3	4.1	11.4	1.0	28.0	69.8	480.9	145.1
1971	27.8	4.1	10.8	1.0	25.0	68.7	366.1	187.7
1976	28.3	4.1	10.9	0.9	24.2	68.4	338.6	202.0
1981	30.9	4.1	9.7	1.4	19.8	65.9	318.4	207.0
1986	33.2	3.6	8.5	0.7	21.8	67.8	293.1	231.3
1991	33.5	4.1	7.9	..	..	67.8	280.0	242.1

Note:
1. Other land refers to barn yards, laneways and other unclassified lands.
Source:
Statistics Canada, Agriculture Division.

to 280 thousand in 1991. At the same time, the average farm size has increased five-fold, from approximately 50 hectares in 1901 to 242 hectares in 1991. Reasons for these changes include larger, more specialized operations (agribusiness) and increased mechanization.

As the population grows and the economy expands, more space is required for housing, transportation, recreation and industry. The buffer areas surrounding cities, commonly referred to as the rural-urban fringe, experience competing demands for land that result from urban expansion. Land values in urban fringe areas often increase due to their proximity to cities rather than from their potential as agricultural land. This growing development is driving up the market price for farmland and is causing farmland to be fragmented. The smaller fragments of land are often removed from agricultural production, due to access limitations or conflicts with residents.

Much of the information on agricultural land value comes from Statistics Canada census and survey vehicles. In the *Census of Agriculture*, the value of land used for agriculture is collected as a part of the measure of the value of farm capital. This amount refers to the market value of the farm capital employed in the production of agricultural commodities, whether owned or leased. Historical statistics are shown in Table 9.2.

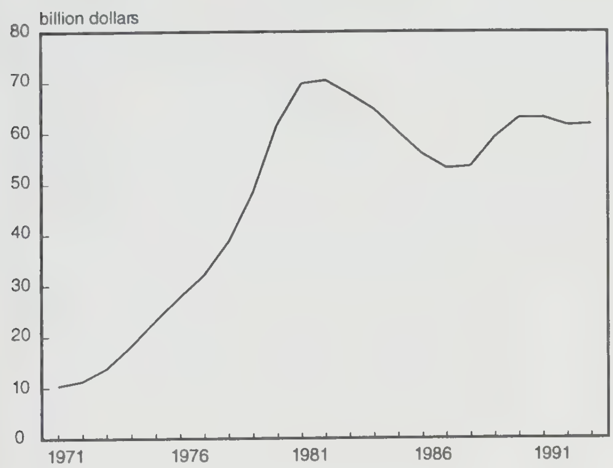
The three components of farm capital are livestock and poultry, land and buildings, and farm implements and machinery. Livestock and poultry include cattle, hogs, sheep, chickens, turkeys, mink and fox on farms. Separate estimates are made for autos, trucks and other farm machinery. The market value of land and buildings used in agricultural

Table 9.2
Value of Agricultural Capital by Province, 1971-1994

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.[1]	**Canada**
	million dollars										
1971	..	161	205	172	2 167	6 868	2 047	5 465	5 202	1 594	**23 882**
1976	71	327	449	350	4 196	16 963	4 534	12 687	13 863	3 602	**57 043**
1981	116	702	907	669	9 513	31 286	10 463	31 355	36 855	8 532	**130 397**
1986	106	735	959	754	9 423	23 663	9 533	29 224	28 531	6 473	**109 400**
1987	116	746	992	769	9 915	23 806	9 328	27 430	27 925	6 277	**107 303**
1988	129	759	1 032	789	10 207	26 528	8 984	26 584	27 656	6 547	**109 216**
1989	143	820	1 094	811	10 782	32 297	9 564	26 745	29 984	7 140	**119 381**
1990	159	927	1 155	872	11 592	35 603	10 290	26 711	31 434	7 891	**126 633**
1991	176	938	1 149	913	11 771	37 517	10 179	25 638	30 559	8 539	**127 379**
1992	178	958	1 145	901	11 777	35 387	10 230	24 934	29 457	8 762	**123 729**
1993	180	963	1 154	905	12 173	34 727	10 661	25 253	30 293	9 643	**125 952**
1994	187	1 053	1 166	915	12 696	34 638	11 154	26 553	32 516	10 693	**131 570**

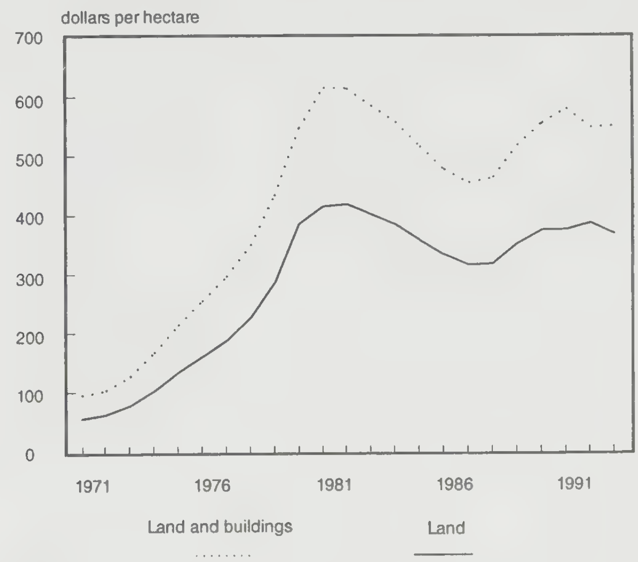
Notes:
Figures may not add due to rounding.
Farm capital includes the value of livestock and poultry, implements and machinery, and land and buildings.
1. The data for British Columbia include values for the Yukon and North West Territories.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 9.1
Value of Agricultural Land, 1971-1993



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Figure 9.2
Value of Land and Buildings and Value of Land per Hectare, 1971-1993



Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

production is reported for holdings with minimum gross sales of $250. It covers the value of all property operated by the holding, whether owned or rented from others, and excludes the value of property rented to others. It also excludes the value of offices not located on the farm, even though these are assets of the farm holding. Current capital values of land and buildings is shown in Table 9.3. Per hectare values are shown in Table 9.4.

The total value of agricultural land has more than quadrupled since 1971 (Figure 9.1). Farmland values steadily increased during the 1970s, peaking at $70.4 billion in 1982. They have since levelled off, reaching $61.7 billion in 1993. However, in heavily populated areas like southern Ontario and southwestern British Columbia, the value of land and buildings has risen by over six hundred percent. In the vicinity of some urban centres, value changes of over two thousand percent have been reported for some farms. Such increased land values make entry into farming prohibitively expensive for new farmers, as increases in agricultural land value and farm purchase prices are typically unmatched by commensurate increases in food prices.

The per-hectare value of agricultural land is shown in Table 9.5. Figure 9.2 shows the value per hectare of agricultural land versus that of land and buildings.

Pilot test area: New Brunswick

Agriculture in Canada occupies a vast area and is very diversified. In order to test a method for land valuation, it is important to choose an area of suitable size and with a variety of characteristics. New Brunswick was chosen for the agricultural land valuation project because of its manageable size (less than 1% of the country's total area) and its diverse mix of land cover and use. Its agriculture industry is sufficiently strong and diversified.

Agricultural land valuation

The farmland values shown in Tables 9.3 to 9.5 are based on the values reported for land and buildings to the *Census of Agriculture*. These values reported by farmers include a speculative element and do not reflect inherent resource quality or the costs associated with using the land resource (i.e. pollution and degradation). To overcome these shortcomings, an alternative approach using the concept of economic rent was employed to value agricultural land.

The use of resources to satisfy human needs has both positive and negative impacts on the environment. These interactions are outlined in Text Box 9.1 and can be related to agricultural production. They are, however, difficult to measure in the context of agriculture because of the many complex externalities. In theory, the summation of the positive and negative effects of the four types of interactions should yield a value of agricultural land in which environmental impacts are considered. For the purposes of this paper, the *environmental hazards and risks* are not

Table 9.3

Value of Agricultural Land and Buildings by Province, 1971-1994

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.[1]	Canada
	million dollars										
1971	..	102	132	107	1 322	5 183	1 374	3 868	3 530	1 293	**16 912**
1976	59	218	312	232	2 718	13 822	3 208	9 298	10 628	3 052	**43 547**
1981	94	479	633	444	6 224	25 299	7 836	25 048	29 961	7 261	**103 278**
1986	78	490	655	489	5 951	17 972	6 584	21 830	20 774	5 264	**80 088**
1987	87	498	678	496	6 194	17 842	6 222	19 649	19 744	4 955	**76 367**
1988	97	506	703	503	6 384	20 481	5 817	18 863	19 159	5 186	**77 698**
1989	107	545	757	520	6 776	26 064	6 266	18 882	21 092	5 704	**86 713**
1990	119	646	813	562	7 366	29 127	6 864	18 807	22 169	6 412	**92 883**
1991	133	656	801	599	7 781	31 022	6 814	17 589	21 291	7 038	**93 724**
1992	134	683	793	588	7 820	28 973	6 814	16 745	20 312	7 242	**90 104**
1993	135	676	785	578	7 929	27 998	7 005	16 474	20 170	8 045	**89 796**
1994	139	775	777	569	8 191	27 448	7 236	17 482	21 441	9 011	**93 068**

Notes:
Figures may not add due to rounding.
Reflects the value of all farm land, including pasture and unimproved land, plus the value of farm houses, buildings, and other structures.
1. The data for British Columbia include values for the Yukon and North West Territories.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Table 9.4

Value of Agricultural Land and Buildings per Hectare by Province, 1971-1994

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.[1]	Canada
	dollars per hectare										
1971	..	326	247	198	301	803	178	146	175	549	**247**
1976	1 816	736	650	499	677	2 207	418	351	526	1 245	**635**
1981	2 800	1 693	1 359	1 006	1 646	4 188	1 013	944	1 483	2 943	**1 520**
1986	2 145	1 796	1 574	1 196	1 636	3 183	850	820	1 006	2 184	**1 181**
1987	2 259	1 846	1 646	1 233	1 722	3 183	803	736	954	2 058	**1 127**
1988	2 382	1 895	1 720	1 273	1 796	3 679	751	707	924	2 157	**1 147**
1989	2 511	2 063	1 871	1 339	1 930	4 715	811	707	1 016	2 377	**1 280**
1990	2 646	2 469	2 026	1 470	2 123	5 305	887	702	1 067	2 676	**1 371**
1991	2 807	2 535	2 016	1 594	2 268	5 691	882	655	1 023	2 941	**1 384**
1992	2 750	2 666	2 016	1 594	2 308	5 352	882	623	976	3 032	**1 329**
1993	2 696	2 666	2 016	1 594	2 367	5 209	907	610	969	3 375	**1 327**
1994	2 696	2 965	2 016	1 594	2 474	5 142	937	645	1 028	3 788	**1 374**

Notes:
Reflects the value of all farm land, including pasture and unimproved land, plus the value of farm houses, buildings, and other structures.
Values are held constant in some years for some provinces when survey results indicate virtually no change.
1. The data for British Columbia include values for the Yukon and Northwest Territories.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

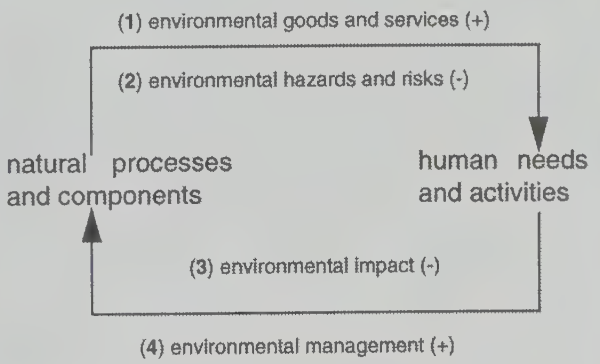
Table 9.5

Value of Agricultural Land per Hectare by Province, 1971-1994

Year	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.[1]	Canada
	dollars per hectare										
1971	..	131	79	82	121	390	126	111	124	334	**151**
1976	860	383	252	257	341	1 191	306	277	371	736	**405**
1981	1 661	993	586	573	872	2 313	764	756	1 070	1 693	**1 028**
1986	1 527	1 176	749	744	922	1 873	660	662	741	1 231	**825**
1987	1 609	1 208	786	766	971	1 873	623	598	702	1 159	**783**
1988	1 695	1 240	818	791	1 013	2 160	588	573	680	1 213	**788**
1989	1 787	1 352	939	833	1 087	2 768	628	573	746	1 339	**872**
1990	1 885	1 616	964	912	1 196	3 114	687	568	786	1 507	**929**
1991	1 999	1 661	959	991	1 280	3 341	684	531	754	1 656	**932**
1992	1 957	1 747	959	991	1 302	3 311	684	504	719	1 708	**959**
1993	1 920	1 747	959	991	1 334	3 314	702	494	714	1 900	**912**
1994	1 920	1 942	959	991	1 490	3 020	726	524	756	2 182	**993**

Notes:
Values are held constant in some years for some provinces when survey results indicate virtually no change.
1. The data for British Columbia include values for the Yukon and Northwest Territories.
Sources:
Statistics Canada, National Accounts and Environment Division and Agriculture Division.

Text Box 9.1
Interrelations between Human Activity and the Environment



The four identified interactions have either a positive or negative effect on the system. The use of *environmental goods and services* benefits human needs and activities in a positive manner. *Environmental hazards and risks*, such as droughts, storms, floods, earthquakes, etc., negatively affect humans. Through numerous activities involving physical, chemical and biological elements, humans negatively affect the natural environment, through the *environmental impact* function. On the other hand, humans can undertake management processes which enhance the environment, through the *environmental management* function.

We can relate this to economic rent by essentially summing the positive and negative effects of each interaction (outlined above) as shown below:

Rent = (1)+(2)+(3)+(4)

Source:
de Groot, 1992; p. 8.

addressed. The *environmental management practices* are reflected in the model in theory, but left out in practice due to data limitations.

Economic rent is the return to a factor of production, or essentially the profit which relates to the use of the resource in production. By classifying the inputs to and the outputs of agricultural production according to the framework in Text Box 9.2, it is possible to estimate an economic rent associated with land in agricultural production.

Methodology

In the case of agricultural production, the difference between outputs and inputs can loosely be considered rent, as shown below:

(a) Outputs - Inputs = Rent

Text Box 9.2
Outputs and Inputs (Market and Non-market) Associated with Agricultural Production

Outputs:

Market production: grains, vegetables, fruits, cattle, poultry, eggs, dairy products, lambs, goats, animal products, plants products, etc.

Positive non-market outputs: farm income in kind, environmental amenities, scenic amenities, land preservation, rural lifestyle, etc.

Negative non-market outputs: fertilizer and manure runoff, soil erosion and sedimentation, water and air pollution, reduction in soil productivity, etc.

Inputs:

Market goods and services: seeds, animal feed, tools, machinery, fuel, electricity, insurance, veterinary care, quotas, labour, etc.

Non-market resources: air, water, time (associated with the opportunity cost of labour), etc.

Farm management irrigation and drainage, contour tillage, crop rotation, cover crops, salinity control. monoculture, summerfallowing, etc.

Note:
The list is not meant to be exhaustive.

Outputs are defined to include all tangible products, as well as the environmental amenities and pollution externalities associated with agricultural production. Inputs are defined to include the market inputs which are paid for, free resources such as air, rain, water and the soil's mineral resources as well as farm management practices. Some of these outputs and inputs are difficult to measure, as can be seen from the sample list in Text Box 9.2. The return to land, or economic rent associated with the land, is equal to difference between the outputs and inputs.Theoretically, if the market value of land reflected the complete social and economic value of the land, then the present value of equation (a) over time would be close to the market value of the land.

Some economic data are readily available for the inputs and outputs. Equation (b) below represents the subset of (a) which can be easily measured:

(b) Revenues - Expenditures = Profits

Revenues include proceeds from sales and other revenues such as rental income, insurance proceeds, quota sale income, and recaptured capital consumption allowances. Expenses include all expenses incurred in the production of

crops, livestock and other agricultural products, as well as general costs such as insurance and wages.

Since the focus of this research is to isolate a return to agricultural land, the value for profit calculated by deducting the expenses from revenues (as identified above) represents only a first step. The set of expenses must be expanded to include those for improvements to the land (e.g., irrigation and drainage systems). The capital cost allowances for buildings and machinery must also be included as they represent a return to the non-land portion of farm capital. Interest payments for loans to purchase or improve the farm must also be deducted from revenue so that what remains as profit is an estimate of the return to the land or economic rent associated with the land.

For the same reason, certain variables should be excluded from the rent equation, namely, subsidy program payments received by the farmer and income and expenses not related to agricultural production. All revenue and expense variables taken into account in the rent equation are listed in Text Box 9.3.

Data requirements

The theoretical model proposed in this paper underscores the importance of both physical and monetary data. Monetary data come from the Taxation Data Program (TDP) of the Whole Farm Data Base (WFDB) (Agriculture Division, Statistics Canada). The TDP consists of a sample of approximately 70 thousand income tax records. The sampling frame covers all provinces and includes all individuals who claim either a positive gross farm income or a non-zero net farm income. Research stations, institutional farms, Hutterite colonies and Indian Reserves are excluded.

The TDP contains detailed information on operating revenues and expenses, additions and disposals of depreciable assets, and off-farm income of farm operators and their families (Statistics Canada, 1994c). The information comes from two sources - a random sample of unincorporated income tax filers (taken from the Self-Employment File for Agriculture) and a random sample of incorporated farm holdings with annual sales over $25 000.

In the WFDB, New Brunswick farms are divided into seven types typically found in the province - dairy, cattle, hogs, poultry, potato, fruit and vegetable, and other - and seven revenue classes. The information is further split between the four *Census of Agriculture* Regions (CARs) of New Brunswick. Confidentiality constraints precluded the calculation of estimates by region.

The model was implemented for 1991, the last available census year.

Text Box 9.3

Variables and Underlying Methodology of Land Valuation Equation

Revenues include:

(1) *Proceeds from sale of:*

a) *grains and oilseeds*: wheat, oats, barley, canola, soybeans, corn, other small grains, other grains and oilseeds.

(b) *Other crops*: potatoes, fruits and vegetables, tobacco, greenhouse and nursery products, forage crops, other crops, unspecified crops.

(c) *Livestock and livestock products*: cattle and semen, swine, poultry and eggs, sheep and goats, dairy products, other livestock products.

(2) *Other revenue*[1]: custom work and machine rental, rental income, insurance proceeds, forest and maple products, cash advances (net).

(3) *Income adjustments*: quota sale income, capital cost allowance recaptured, inventory adjustments, excluding income from the sale of non-farm products.

Expenses include:

(1) *Crop expenses:* fertilizer, lime, pesticides, seed and plants, containers, twine, baling wire, etc.

(2)*Livestock expenses:* animal purchases, feed, supplements, veterinary, medicine and breeding fees, etc.

(3) *Machinery expenses*: small tools, repairs, licenses, insurance, machinery, truck and auto expenses.

(4) *General expenses:* salaries, rent, insurance, phone, electricity, fuel, property tax, building and fence repairs, marketing, miscellaneous expenses.

(5) *Expense adjustments:* clearing and improving land, inventory adjustments, capital cost allowance (depreciation and estimated return on investment in fixed capital) interest payments on mortgage and improvement loans.

If only revenues and expenses associated with agricultural production are taken into account, including an estimated return on investment in fixed capital, the difference between the two is the intrinsic value, or rent, of agricultural land:

Revenues less Expenses = Land Rent

Note:
1. This excludes both *program payments* and *miscellaneous revenues*. Program payments include stabilization payments such as Net Income Stabilization Account (NISA), Gross Revenue Insurance Program (GRIP), Special Grains Programs, Christmas tree grants, subsidies other than dairy, and other payments and reimbursements. Miscellaneous revenues include GST refunds, horse racing income, etc.

Results

The results of the two methods of valuing New Brunswick's agricultural land for 1991 are dramatically different:

i) The value of agricultural land estimated on the basis of farm real estate values reported to the *Census of Agriculture* is **$371.6 million**.

ii) The present value of rent on land estimated with the model (discounted at a 5% interest rate over a 25 year period) is **$5.5 million**.

The first estimate, which is presently incorporated in the national balance sheet, is over sixty times larger than the alternative one based on rent. The large discrepancy between the two can be attributed to several factors.

First, farm income was abnormally low in New Brunswick in 1991, and this depressed the model results. The difference would likely have been smaller if another year's farm income or an average of many years had been used instead. However, this will account for only part of the difference.

Second, the real estate values reported to the Census reflect the proximity to urban areas. The value of farms close to urban areas is driven up by the need of cities for additional land. Also, farm ownership is a long-term investment. The farmer expects to sell or liquidate his farm at a value that has appreciated over time. This will influence the property value he reports to the Census. The model purposely excludes these factors.

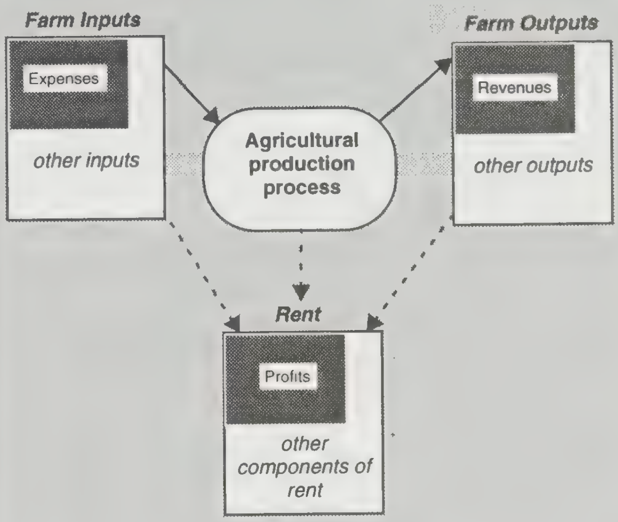
Third, as shown in Text Box 9.2, there are several inputs and outputs associated with agricultural production which cannot be measured, either because they are not traded in the market place or data are simply unavailable. The inputs (that is, farm expenses) and outputs (that is, farm revenues) used in the model – represented by the shaded portions of the boxes in Text Box 9.4 – are only a subset of the actual inputs and outputs of agricultural production. The profit used as a proxy for rent to land is derived from this subset and is also a subset of the actual rent. If the model were based on a more complete set of inputs and outputs, the rent would be more comprehensive.

There are more outputs than inputs which are difficult to measure with market scenarios, for example, the socio-economic benefits associated with agriculture. Inputs are typically more measurable, although items such as agricultural management practices may be hard to quantify in an economic framework. Data are available, however, at both the provincial and regional levels on farm participation in certain agricultural practices. Although difficult to integrate in the model, participation in these practices is known to change the value of agricultural land.

Conclusion

The purpose of this paper was primarily to develop a model for land valuation. The benefits were twofold: (1) a preliminary estimate of the rent, or value, associated with land employed in agricultural production, and (2) an indication of data needed to ensure that the model yielded a representative value for agricultural land.

Text Box 9.4
Illustration of the Model



Note:
This diagram is not intended to represent the magnitude of undercoverage in the model.

The model determined land rents by relating revenues and expenses to the inputs and outputs associated with agricultural production. Although the results were much lower than those based on the *Census of Agriculture*, they are conceptually more compatible with the definition of economic rent.

There are a number of factors which affect the value of land employed in agricultural production, some of which are either immeasurable or not currently measured. However, estimates could be developed to reflect the value of the land as a resource employed in production. An example would be the information on soil conservation practices found in the Environment Information System. In the future, the EIS may be used to develop meaningful data which could be added to the model. Data for additional years and more complete estimates of social and environmental costs and benefits would also enhance the reliability of the model.

The agricultural land valuation initiative should now focus on developing statistics to fill the information gaps. The model should also be applied to other provinces.

References

Adamowicz, W.L., 1991, "Valuation of Environmental Amenities", *Canadian Journal of Agricultural Economics*, Volume 39, p. 609-618.

de Groot, R.S., 1992, *Functions of Nature – Evaluation of Nature in Environmental Planning, Management and Decision Making.*

Environment Canada, 1980, *Land Use in Canada – The Report on the Interdepartmental Task Force on Land-Use Policy*, No. En72-7/1980, Ottawa.

Pearce, D.W., and R.K. Turner, 1990, *Economics of Natural Resources and the Environment*, John Hopkins University Press, Baltimore.

Ritson, C., 1977, *Agricultural Economics – Principles and Policies*, St. Martin's Press, New York.

Statistics Canada, 1994a, *Human Activity and the Environment 1994*, Catalogue No. 11-509E, Ottawa.

_____, 1994b, *National Balance Sheet Accounts*, Catalogue No. 13-214, Ottawa.

_____, 1994c, *Whole Farm Data Base Reference Manual*, No. 21C0005GPE, Ottawa, p. 2.

_____, 1995, *Environmental Information System Reference Guide*, May, Ottawa.

Taylor, H.C., 1952, *The Story of Agricultural Economics in the United States*, Iowa States College Press, Ames.

United Nations, Commission of the European Communities-Eurostat, International Monetary Fund, Organization for Economic Co-operation and Development and World Bank, 1993, *System of National Accounts*, ST/ESA/STAT/SER.F/2/Rev.4, New York.

Van Kooten, 1992, *Land Economics: An Introduction to the Resolution of Land Use Conflicts*, University of British Columbia Press, Vancouver.

10 Canada's Commercial Fishery: A Statistical Profile

by Dale Austin[1]

Introduction

Canada's natural resources include forests, sub-soil deposits, abundant and varied land and water types, fish and other wildlife. Produced assets, such as roads or machinery, are taken into consideration for the calculation of national wealth but, with the exception of some of Canada's land, natural resources are currently left off the balance sheet.

In recent years, there has been an increased awareness of the social and economic costs associated with utilizing natural resources. The failure of economic indicators such as Gross Domestic Product (GDP) to take account of environmental quality issues has been criticised. Part of the solution to these issues is to measure the effects of human and economic activity on the environment by explicitly including the value of natural resources and their depletion as part of the national balance sheet.

A physical stock account for the fishery would include population counts for all economically important species in a given geographic location for any year. Monetary accounts would show the value of the stocks and harvest. The stock value would be included in Canada's balance sheet as part of the nation's wealth. The stock that is relevant to national wealth is what is considered an economic asset, the part which can be "owned" by Canada and which is economically exploitable.

Physical stock data

Ideally, a physical account for the fishery would provide population estimates for all species. However, population estimates are sporadic at best. There is a lack of comprehensive, systematic quantitative data relating to productivity, biotic composition, disease outbreaks and contaminants for all species. There is a scarcity of long-term indicators as data gathering has been restricted to specific regions and/or short-term studies. Canadian scientists do not have the technology or resources to regularly study the many species of aquatic life that inhabit Canada's vast oceanic and fresh water territory. When counts do exist they are often separated by many years and occur in different years for different species.

In general, there are abundant and high quality data for fish harvests but a lack of data reporting the status of Canada's fish stocks. More frequent and reliable stock data, ideally for all species but most significantly for commercial species, would allow the development of time-series data and the ability to identify trends in stock status. A more complete set of fisheries statistics would allow a more comprehensive examination of the status of the fishery.

Table 10.1 illustrates the fluctuations in harvest volume of the Canadian fishery for the period 1961-1994. The steady decline in the catch between 1971-1974 can be explained to some extent by implementation of total allowable catch (TAC) restrictions in an effort to reduce the harvest and preserve fish stocks. Some of the increase that begins in 1977 can be attributed to the extension of Canada's Exclusive Economic Zone to the present 200-mile limit. The sharp decline in harvests in the last four years represents the decline of the groundfish stocks off Canada's east coast.

Economic trends in the fishery industries

Resource rent

The concept of rent is the basis of valuation of a natural resource. Rent is the value of the resource itself, the residual left when all the costs of bringing the resource to a market are subtracted from the selling price. The annual rent earned by the fishery can be used to estimate the value of the resource stock. The stock could be valued as an asset which will provide an indefinite flow of rent in the future. The value would be the present value of the future rent. This method in effect assumes that the annual harvest rate on which the rent calculation is based can be sustained, although recent history in the Canadian fishery has shown that harvest levels have not been sustainable. Using such a method would overestimate the value of the asset.

Due to the lack of detailed data, calculating a value based on the characteristics of the fish stocks is impractical. Instead, a rent residual has been calculated using annual historical data for the fishing and trapping industry. GDP includes all costs (labour cost and capital cost allowance) as well as a return to entrepreneurship and to the resource. Depreciation and profit are not calculated separately, but are part of industry's operating surplus. A residual rent calculation, subtracting estimated data for depreciation and a return to capital from the industry surplus time series at the national total level, gave results that were judged unacceptable. A rent residual was also calculated for the year 1990 by province. This calculation showed that a low national aggregate was made up of negative and positive provincial

1. The author would like to thank Gerry Gravel, Rob Smith, Alice Born and Rick Moll for their patience and guidance in the preparation of this paper.

Table 10.1
Ocean Fishery Harvest by Province, 1961-1994

	Newfoundland		Prince Edward Island		Nova Scotia		New Brunswick		Quebec		British Columbia		**Canada**	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	**Quantity**	**Value**
1961	253 469	14 922	17 947	4 489	253 185	27 741	70 035	7 625	53 694	4 228	297 000	39 700	**945 330**	**98 705**
1962	276 719	17 454	18 584	4 649	262 073	32 063	95 767	9 038	65 495	5 170	319 800	49 100	**1 038 440**	**117 474**
1963	295 218	20 423	18 789	4 625	267 379	36 228	111 020	9 287	64 915	5 623	357 700	40 500	**1 115 020**	**116 686**
1964	289 348	22 873	20 598	5 751	309 667	42 436	119 248	10 263	64 754	6 132	332 300	48 400	**1 135 920**	**135 855**
1965	303 796	24 101	23 514	7 083	354 207	49 371	136 182	10 546	70 860	6 458	294 100	47 500	**1 182 660**	**145 059**
1966	332 680	26 575	28 434	6 504	404 446	49 456	159 471	11 067	70 259	6 939	271 500	60 700	**1 266 790**	**161 241**
1967	383 613	28 922	22 163	8 187	380 677	48 211	163 243	10 838	90 971	7 417	159 800	49 600	**1 200 470**	**153 175**
1968	465 626	28 843	24 428	8 571	429 024	54 601	250 356	15 564	98 105	8 148	131 100	57 400	**1 398 640**	**173 127**
1969	484 743	30 786	25 274	8 832	364 757	56 529	235 643	15 874	97 132	8 712	88 400	47 400	**1 295 950**	**168 133**
1970	471 846	36 123	48 909	11 174	320 790	55 557	206 768	17 639	125 646	10 914	117 000	60 300	**1 290 960**	**191 707**
1971	418 866	36 811	46 923	10 361	347 559	59 433	165 868	16 089	115 528	10 559	113 400	58 600	**1 208 140**	**191 853**
1972	315 512	36 512	28 214	10 136	338 305	67 949	161 214	19 810	87 989	10 716	162 300	75 100	**1 093 530**	**220 223**
1973	324 686	47 877	30 312	12 414	328 019	75 972	130 532	22 041	74 929	12 755	183 800	130 400	**1 072 280**	**301 459**
1974	249 605	42 874	17 715	12 031	344 475	81 166	112 431	21 852	56 777	13 650	141 100	101 000	**922 103**	**272 573**
1975	255 576	45 785	16 313	12 416	356 457	92 648	120 496	25 327	56 503	14 643	133 000	79 700	**938 345**	**270 519**
1976	339 211	64 716	17 134	12 719	367 883	106 686	114 709	24 838	41 955	15 131	180 900	141 800	**1 061 790**	**365 890**
1977	392 786	85 479	19 801	15 164	407 074	133 145	129 117	34 069	54 296	20 377	204 350	167 905	**1 207 420**	**456 139**
1978	463 959	118 364	25 660	23 376	444 869	195 388	151 393	49 616	67 350	29 255	198 703	252 192	**1 351 930**	**668 191**
1979	569 107	159 258	31 059	29 377	421 154	225 527	137 217	53 620	79 165	40 017	155 276	332 468	**1 392 980**	**840 267**
1980	499 199	161 286	33 463	26 772	436 822	510 075	105 356	48 575	81 248	41 870	129 926	182 281	**1 286 010**	**970 859**
1981	498 721	170 765	38 515	31 786	467 473	264 124	102 257	54 586	87 591	46 790	183 137	236 181	**1 377 690**	**804 232**
1982	504 458	176 287	36 788	35 841	460 792	259 593	109 001	67 067	86 593	50 387	157 843	240 010	**1 355 480**	**829 185**
1983	455 839	167 419	40 424	42 926	425 854	276 512	107 919	79 375	78 403	55 952	191 543	209 787	**1 299 980**	**831 971**
1984	450 583	..	54 300	..	402 778	..	99 130	..	83 877	..	166 906	..	**1 257 570**	..
1985	468 693	..	54 582	..	466 341	..	136 024	..	90 189	..	214 934	..	**1 430 760**	..
1986	515 998	..	60 264	..	462 787	..	143 204	..	89 973	..	225 889	..	**1 498 120**	..
1987	499 727	..	56 723	..	493 442	..	151 595	..	97 277	..	251 531	..	**1 550 300**	..
1988	554 414	292 096	57 909	68 997	514 474	436 904	151 668	118 411	88 231	99 193	271 304	533 559	**1 638 000**	**1 549 160**
1989	506 724	245 310	34 432	62 918	463 603	437 805	150 844	97 457	79 098	82 491	284 036	453 664	**1 518 740**	**1 379 650**
1990	537 369	279 516	43 009	45 567	449 725	444 868	153 108	91 929	74 330	74 140	301 293	478 192	**1 558 830**	**1 414 210**
1991	426 829	261 378	49 037	69 118	503 009	495 474	116 780	96 324	73 870	85 487	310 282	405 740	**1 479 810**	**1 413 520**
1992	280 539	199 121	47 330	79 715	491 460	511 572	126 059	104 850	70 425	88 881	292 991	416 126	**1 308 800**	**1 400 270**
1993	226 688	..	32 985	..	400 930	..	115 482	..	58 307	..	275 081	422 463	**1 109 470**	..
1994	133 511	..	32 372	..	307 999	..	124 754	..	48 006	..	137 626	..	**784 268**	..

Notes:
All quantities are expressed in tonnes.
All values are expressed in thousand dollars.
Sources:
Department of Fisheries and Oceans Canada, Biological Sciences and Industry Development and Programs directorates.

components. This indicates that while the rent value may be low in aggregate at the national level, there could be regions where the fishery rents are relatively important. The provincial calculation was based on the same data as the national calculation and so, it too was considered unacceptable.

A low or zero rent value for fish resources would not be unexpected. In the absence of (worldwide) regulation, common property resources can be exploited to the point where the market price of the resource falls below the full cost of exploitation. A time series of the value of Norway's fish stocks was recently estimated as consistently near zero (Statistics Norway, 1995). A study by the Economic Council Of Canada concluded:

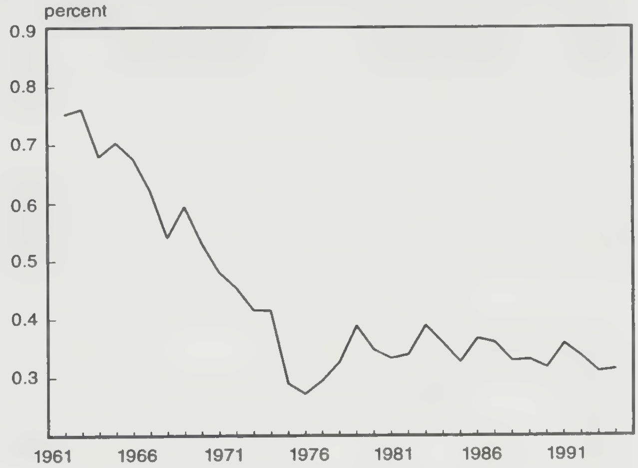
> If the administration costs associated with the Canadian fishery are subtracted it would be difficult to conclude that the net Canadian wealth generated annually by the regulated fishery is even positive. There is no compelling evidence that the Canadian fisheries, taken together, yield a net surplus. In short, the potential wealth of the Canadian fishery has been dissipated (Scott and Neher, 1981; p. 26).

Value added

The fishing industry contributes directly and indirectly to the Canadian economy in a variety of ways. Harvesting, transportation, processing and other margins related to both fish and fish products all contribute to employment and GDP. Statistics Canada defines two industries related directly to fishing in its Standard Industrial Classification: the fishing and trapping industry and fish products industry. The fishing and trapping industry's value added (contribution to GDP) was approximately $1 billion in 1993, while that of the fish products industry was just under 800 million (Table 10.2).

Together these industries represented about 0.35% of total GDP in 1993. This percentage was lower than it had been at some points in the past however. Figure 10.1 shows a decline of these industries as a percentage of GDP between 1961 and 1993 from around 0.75% in the early 1960s to the 0.35% just mentioned. The lowest point in the time series came in 1975, when these industries' share of GDP was just 0.27% Since that time, their share has fluctuated between 0.31% and 0.35%.

Figure 10.1
Fishery Industries' Share of GDP, 1961-1993



Source:
Statistics Canada, National Accounts and Environment Division.

Employment

In 1993, total Canadian employment was close to 13 million persons. In the same year, there were approximately 62 thousand people employed in the fishing industries, representing about 0.48% of the work force. This was essentially the situation that existed in 1970 as well, when 37.5 thousand people, or about 0.47% of the total work force, earned their living from these industries (Table 10.2). Figure 10.2 shows employment in these industries as a percentage of the employed work force for the period 1970-1993. As was noted above with respect to value added, the percentage of the total employment represented by the fisheries industries declined to its lowest value (0.41%) in 1975.

Table 10.2
Fishery Industries - Employment and Value Added, 1961-1993

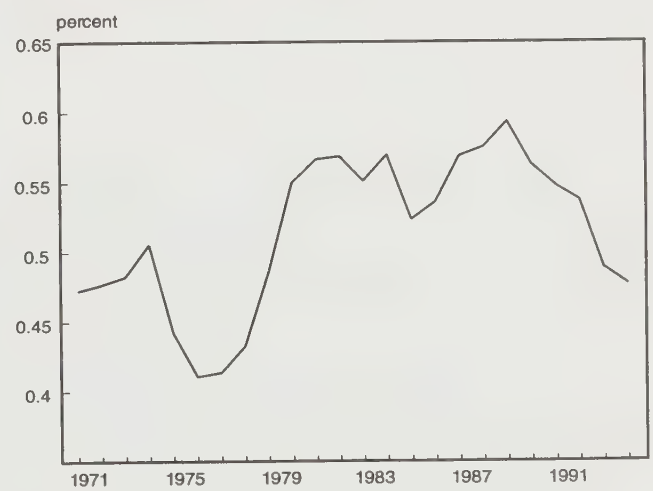
	Employment			Value added		
Year	Fishing and trapping industry	Fish products industry	Total	Fishing and trapping industry	Fish products industry	Total
	workers			million 1986 dollars		
1961	16 223	..	..	772	502	1 274
1962	19 426	..	..	799	582	1 381
1963	22 396	..	..	780	515	1 296
1964	23 047	..	..	788	643	1 431
1965	20 039	..	..	741	724	1 466
1966	23 118	..	..	821	618	1 439
1967	22 125	..	..	752	537	1 289
1968	22 135	..	..	926	565	1 491
1969	18 891	..	..	750	654	1 404
1970	18 174	19 254	37 428	781	526	1 307
1971	20 149	18 510	38 659	725	579	1 304
1972	20 157	20 100	40 257	666	598	1 264
1973	22 848	21 424	44 272	678	678	1 357
1974	21 564	18 774	40 338	575	418	993
1975	21 136	16 987	38 123	536	420	956
1976	19 622	19 568	39 190	610	488	1 098
1977	19 834	21 937	41 771	722	538	1 260
1978	23 257	25 231	48 488	785	782	1 567
1979	29 175	27 995	57 170	706	752	1 458
1980	33 588	27 084	60 672	728	690	1 417
1981	35 076	27 486	62 562	834	662	1 496
1982	33 115	25 382	58 497	900	762	1 662
1983	36 240	24 577	60 817	852	727	1 580
1984	32 848	24 372	57 220	777	753	1 530
1985	33 161	26 964	60 125	945	854	1 800
1986	36 637	28 934	65 571	980	846	1 826
1987	37 044	31 171	68 215	886	852	1 738
1988	41 562	31 086	72 648	946	889	1 836
1989	39 751	30 498	70 249	1 023	780	1 803
1990	41 219	27 617	68 836	1 129	898	2 027
1991	43 721	25 643	69 364	1 023	849	1 873
1992	38 271	24 409	62 680	992	747	1 739
1993	40 157	21 839	61 996	1 020	779	1 799

Note:
Figures may not add due to rounding.
Source:
Statistics Canada, National Accounts and Environment Division.

Imports and exports

Canada is a net exporter of fish products. During the period 1971-1993, the value of fish product exports was consistently 3-5 times higher than the value of imports. Put in the context of the nation's total external trade, fish products represented a substantial 1.6% of merchandise exports in

Figure 10.2
Fishery Industries' Share of Total Employment, 1970-1993



Source:
Statistics Canada, National Accounts and Environment Division.

1971. This figure had dropped only slightly to 1.5% by 1993. Over the period 1971-1993, fish product exports as a percentage of total merchandise exports peaked at 2.3% in 1987; their smallest export share, 1.3%, occurred in 1974 and 1975 (Table 10.3).

Aquaculture[1]

In an effort to mitigate the effects of resource depletion in the traditional fishery, some fishers have been turning to aquaculture as a viable alternative source of income. As fisheries world-wide reach their catch limits there will be increased pressure to find new sources of fish. The unpredictable rise and fall of fish stocks from season to season, as well as the long-term decline in some species, has led to aquaculture as an attempt at ensuring an alternative, sustainable supply of fish.

Table 10.3
Imports and Exports of Fish Products, 1971-1993

Year	Exports		Imports	
	Total	Percentage of total merchandise exports	Total	Percentage of total merchandise imports
	million dollars	percent	million dollars	percent
1971	276	1.6	60	0.4
1972	340	1.7	81	0.4
1973	484	1.9	110	0.5
1974	418	1.3	119	0.4
1975	451	1.3	134	0.4
1976	590	1.5	182	0.5
1977	795	1.8	220	0.5
1978	1 111	2.1	248	0.5
1979	1 271	1.9	310	0.5
1980	1 265	1.6	354	0.5
1981	1 494	1.8	360	0.5
1982	1 591	1.9	352	0.5
1983	1 564	1.7	417	0.6
1984	1 595	1.4	488	0.5
1985	1 849	1.6	494	0.5
1986	2 554	2.1	613	0.6
1987	2 906	2.3	691	0.6
1988	2 841	2.1	679	0.5
1989	2 564	1.8	738	0.5
1990	2 624	1.8	679	0.5
1991	2 455	1.8	736	0.5
1992	2 504	1.6	777	0.5
1993	2 650	1.5	996	0.6

Source:
Statistics Canada, International Trade Division.

Aquaculture is the managed rearing of aquatic organisms including fish, molluscs, crustaceans and plants. The process requires regular intervention in the rearing process to enhance production. Interventions include regular stocking, feeding and protection from predators (Department of Fisheries and Oceans, 1995).

Commercial aquaculture takes place in all 10 provinces and the Yukon territory. In 1994, over four thousand aquaculture sites were in operation across the country. The principal species produced by the industry are salmon, trout, mussels and oysters. Atlantic salmon, mussels, quahogs and steelhead trout (salmo gairdneri) are farmed primarily in the Atlantic provinces. Trout production is concentrated in the central provinces (mainly Ontario), salmon and oyster production primarily in British Columbia and New Brunswick, and mussel production off Prince Edward Island.

Over the past decade, the relative importance of aquaculture has been steadily increasing in the fishing industry. The aquaculture industry grew from a $13 million business in 1983 to nearly $300 million in 1994 (Table 10.4). In 1992, the industry represented roughly 3.5% of the total harvest of the traditional fishery and almost 18% of the total landed value. Despite these gains, aquaculture remains relatively small when compared with the traditional fishery. The total harvest of the traditional fishery at its peak in 1990 was more than 40 times the size of the aquaculture harvest in that year. However, we now know that harvest levels in some of the traditional fisheries were unsustainable; aquaculture's importance seems likely to grow as a result.

Factors often cited as retarding the growth of aquaculture in Canada are our cold-water environment and the abundant wild fishery resources available, notwithstanding the apparent shortages of Atlantic groundfish and Pacific salmon. Inadequate treatment of municipal and industrial wastes can also pose a threat to a viable aquaculture industry in certain regions (Department of Fisheries and Oceans, 1995).

Conclusion

The attempt at valuing Canada's fish stocks made for this study indicates a very small contribution to wealth at the na-

Table 10.4
Aquaculture Production, 1983-1994

Year	Quantity	Value
	kilotonnes	thousand dollars
1983	5.7	12 551
1984	6.9	18 247
1985	8.4	23 724
1986	10.5	35 106
1987	13.9	61 669
1988	21.5	105 355
1989	30.3	139 137
1990	36.5	195 955
1991	44.6	257 087
1992	46.9	259 957
1993	50.4	289 274
1994	53.6	296 878

Source:
Davies, 1996.

1. Unless otherwise noted, this section is drawn from Statistics Canada (1994; p. 268-269).

tional level. It appears though that these stocks do contribute significantly to regional economic wealth on the east and west coasts. Without improved data on which to base the estimates, nothing more than these qualitative statements is possible.

The other economic indicators presented in this chapter point to a small but stable contribution by the fisheries to economic life in Canada. The landed value of the ocean fishery harvests has grown considerably over the last three decades, although recent years have seen declines in both Newfoundland and British Columbia. The share of GDP represented by the fishing industries was considerably smaller in the early 1990s than it had been 30 years previous, though most of this decline took place before 1975. Between 1975 and 1993, the share of GDP represented by these industries was quite stable. The latter is also mainly true of their share of employment and of the export share held by fish products. The aquaculture industry stands in stark contrast to this constancy, having shown remarkable growth since the early 1980s.

References

Davies, T., 1996, Personal communication, Department of Fisheries and Oceans, Aquaculture Division, Ottawa.

Department of Fisheries and Oceans, 1995, *Federal Aquaculture Development Strategy*, Ottawa.

Scott, Anthony and Philip A. Neher, 1981, *The Public Regulation of Commercial Fisheries in Canada*, Economic Council of Canada, Ottawa.

Statistics Canada, 1994, *Human Activity and the Environment 1994*, Catalogue No. 11-509E, Ottawa.

Statistics Norway, 1995, *Natural Resources and the Environment 1994*, Oslo.

Annex 1: Selected Environment Statistics for Canada, Mexico and the United States

Table A1.1

Selected Population, Economic, Waste and Natural Resource Statistics, 1993

Characteristic	Source	Canada	Mexico	United States
Total area (thousand km²)	g	9 971	1 958	9 373
Land area (thousand km²)	b,g	9 215	1 953	9 167
Population (thousands)	c,m	28 947	91 210	257 908
Population growth rate 1988-1993 (annual percent)	i	1.2	2.2	1.0
Population density (persons per km²)	b,c,g	3.1	46.7	28.1
Urbanization (percent)[1]	k	78.1	75.3	76.2
Life expectancy[2] (years)	k,n	78.0	70.3	75.9
Males	a,n	74.9	69.7	72.8
Females	a,n	81.0	77.1	79.7
Infant mortality (per 1000 live births)	j,n	6.3	35.4	8.6
Literacy rate[3] (percent)	b,h	99.0	87.1	99.0
Male	k	99.0	90.0	99.0
Female	k	99.0	85.0	99.0
Expenditures on education[4] (percent of GDP)	b,j	6.1	6.2	6.3
Economy				
GDP (million C$)[5]	d,f	705 952	466 877	8 075 271
GDP, PPP method (million C$)[6]	d,f	704 340	802 998	7 887 474
Average annual GDP growth 1981-93 (percent)	d	2.2	1.3	2.5
GDP per capita, PPP method (thousand C$)[6]	c,d	24 332	8 804	30 583
GDP distribution by sector (percent)[7]				
Agriculture and mining[8]	e	5.3	8.2	3.5
Manufacturing and utilities[9]	e	20.0	21.1	20.7
Services, etc.[10]	e	74.6	70.7	74.2
Exports[11] (million C$)	d,j	187 282	39 011	599 553
Exports as a proportion of GDP (percent)	d,j	26.5	8.4	7.4
Motor vehicles (per 1000 persons)	c	594	130	752
Road network (kilometres)	c	930 000	245 000	6 287 000
Wastes				
Municipal waste generated[12] (thousand tonnes)	c	18 800	28 090	187 790
Municipal waste generated (kilograms per capita)	c	660	310	730
Household waste generated[13] (kilograms per capita)	c	360	250	..
Hazardous wastes (kilograms per million C$ GDP) (PPP)	c,k	11 054	9 589	34 992
SO_x emissions (kilograms per million C$ GDP) (PPP)	c,k	4 302	1 370	2 475
NO_x emissions (kilograms per million C$ GDP) (PPP)	c,k	2 753	575	2 672
CO_2 emissions[14] (tonnes of carbon per capita)	k	15.21	3.92	19.53
Greenhouse gas emissions (global per capita rank[15])	l	12	67	8
Global share (percent)	l	1.7	2.0	18.4
Emissions of greenhouse gases[16] (thousand tonnes)	c	459 390	336 724	5 128 734
Consumption of CFC's and halons[17] (tonnes)	h	15 302	14 793	145 593
Per capita (kilograms)	h	0.58	0.17	0.88
Particulate emissions[18] (thousand tonnes)	c	1 855	354	7 080
Volatile organic compound emissions[18] (thousand tonnes)	c	2 014	231	20 287
Resources				
Water				
Renewable supply (km³)	c	2 792.0	414.0	2 478.0
Per capita (thousand m³)	a,b,c	96.5	4.5	9.6
Total use[19] (km³)	c	45.1	77.6	468.6
Per capita (m³)	a,b,c	1 557.9	851.0	1 817.0
Irrigation, share of cropland area[20] (percent)	k	2	21	10
Water withdrawal (percent of available resources)	h	2	15	19
Minerals				
Metal reserve index[21] (world = 100)	b,l	6.1	1.9	8.7
Forest products				
Roundwood production (million m³)	c	180	23	496
Fish				
Fish catches - inland and marine (thousand tonnes)	c	1 172	1 201	5 939

Table A1.1

Selected Population, Economic, Waste and Natural Resource Statistics, 1993 (continued)

Characteristic	Source	Canada	Mexico	United States
Energy				
Energy production[22] (PJ)	k	11 851	8 053	67 936
Solid	k	1 620	220	22 084
Liquid	k	3 819	6 574	18 055
Gas	k	4 374	948	19 509
Electricity				
Geothermal and wind	k	0	190	568
Hydro	k	1 111	87	1 038
Nuclear	k	926	33	6 683
Energy production per capita (GJ)	k	409.4	88.3	263.4
Energy consumption[22] (PJ)	k	8 779	4 834	80 839
Energy consumption per capita (GJ)	k	303.3	53.0	313.4
Energy consumption per C$ GDP (MJ) (PPP)	d,k	12.5	6.0	10.2
Energy production/consumption (ratio)	k	1.3	1.7	0.8
Land[23]				
Protected areas (percent of total)	k	5.0	5.1	10.5
Protected areas (thousand km^2)	k	494.5	99.0	984.6
Expenditure on environmental protection as a percent of GDP[24]	h	0.9	..	0.6
Marine and coastal protected areas[25](thousand hectares)	k	7 106	1 119	54 317
Major protected areas[26]				
Number of sites[27]	c	640	65	1 466
Total size (km^2)	c	892 749	97 287	1 041 069
Percentage of national territory	c	8.9	5.0	10.6
Protected area (hectares per thousand inhabitants)	c	3 105	107	404
International protection systems[28]				
National parks				
Number	c	251	33	176
Area (km^2)	c	366 169	15 978	219 952
Percentage of national territory	c	3.7	0.8	2.2
Protected area (hectares per thousand inhabitants)	c	1 273.5	17.5	85.3
Biosphere reserves				
Number	c	6	6	47
Area (km^2)	c	10 500	12 885	270 291
Heritage sites				
Number	k	6	1	10
Area (km^2)	k	14 710	528	4 357
Wetlands of international importance				
Number	k	30	1	11
Area (km^2)	k	13 016	47	1 192
Land use				
Cropland (thousand km^2)	c	414.29	247.30	1 877.76
Permanent pasture (thousand km^2)	c	263.25	744.99	2 391.72
Forest and woodland (thousand km^2)	c	4 161.75	487.00	2 981.36
Other (thousand km^2)	c	4 381.68	429.40	2 322.27
Wilderness[29] (thousand km^2)	l	6 406	31	441
Land use (percent of total land area)				
Cropland	b,c	4.5	12.7	20.5
Permanent pasture	b,c	2.9	38.1	26.1
Forest and woodland	b,c	45.2	24.9	32.5
Other	b,c	47.5	22.0	25.3

Table A1.1
Selected Population, Economic, Waste and Natural Resource Statistics, 1993 (concluded)

Characteristic	Source	Canada	Mexico	United States
Wilderness[30] (percent of total land area)	b,g,l	69.5	1.6	4.8
Percent change, 1979/81-1989/91				
Cropland	k	0.5	0.7	-1.5
Permanent pasture	k	0.9	0.0	0.7
Forest and woodland	k	5.4	-11.4	-2.5
Other	k	-3.7	12.1	4.4
Average annual fertilizer use, 1989-1991 (kilograms per hectare of cropland)	k	46	69	99
Wildlife				
Threatened species[31]				
Mammals	c	15	143	49
Birds	c	23	339	79
Vascular plants	c	83	902	118
Fish	c	47	140	64
Reptiles	c	30	476	26
Amphibians	c	10	199	8
Invertebrates	c	..	51	..
Extinct[32]	h	4	17	87

Notes:
The reader should note that data collection methods vary considerably from country to country. Caution should be used when interpreting the information. Although many countries adhere to United Nations guidelines for economic, demographic and social data collection, most have adapted these definitions and methods to better suit the local conditions. In addition, the collection of environmental data has often not reached the level of standardization that is found in these other fields. Attention should be given to the footnotes accompanying the table.
1. 1995 estimate.
2. 1990-1995 estimate.
3. 1990 estimate. Adult literacy is only regularly monitored in developing countries. For industrial countries where the adult literacy rate is near 100%, values of 99% are substituted.
4. 1990: Canada and United States; 1995: Mexico.
5. GDP calculated using United Nations definitions.
6. PPP - Purchasing Power Parity, using United Nations definitions.
7. 1991 figures: Canada and the United States; 1993: Mexico. GDP does not include imputed bank service charge, import duties, value added tax and other adjustments.
8. Includes agriculture, hunting, forestry, fishing, mining and quarrying.
9. Utilities include electricity, gas and water.
10. Includes wholesale and retail trade, restaurants, hotels, transport, storage, communication, finance, insurance, real estate, business services, community, social and personal services, producers of government services and other services.
11. Million C$ f.o.b. (free on board).
12. Municipal waste is waste collected by, or on the order of, municipalities. It includes waste originating from households, commercial activities, office buildings, institutions such as schools and government buildings, and small businesses that dispose of waste at the same facilities used for municipally collected waste. Household waste is waste generated by the domestic activity of households.
13. Includes garbage, bulky waste and separately collected waste.
14. 1991 data. Total metric tons from solid, liquid and gaseous fuels, from gas flaring and from cement manufacture.
15. 1989 data. Where number one is the highest per capita producer of greenhouse gases.
16. 1993 data or latest available year from 1990 on.
17. 1990 data.
18. Man made emissions. Data refer to 1993 or to the most recent year from 1990.
19. 1993 data: Canada and Mexico; 1990: United States.
20. 1989-1991 data.
21. 1990 figures: Canada and United States; 1994: Mexico.
22. 1991 data.
23. IUCN categories I-V.
24. 1989 data: Canada; 1990: United States.
25. 1989 data.
26. IUCN management categories I-V. National classifications may differ. Includes only areas greater than 10 km^2 except for islands.
27. Number of sites for which size is known.
28. IUCN category II: national parks and equivalent reserves.
29. Mid-1980s data.
30. Wilderness is not mutually exclusive from the other land use categories and therefore the land area should not be compared with the other categories.
31. Early 1990s data. "Threatened" refers to the sum of the number of species in the "endangered" and "vulnerable" categories.
32. 1990 data. U.S.: excludes the Hawaiian Islands.

Sources:
a. Central Intelligence Agency, *The World Factbook 1995*, Washington D.C., 1995.
b. Instituto Nacional De Estadistica, Geografia E Informatica (INEGI), *Direccion General De Contabilidad Nacional, Estudios Socioeconomicos Y Precios*, 1996 (personal communication).
c. Organisation for Economic Co-operation and Development, *OECD Environmental Data: Compendium 1995*, Paris, 1995.
d. Organisation for Economic Co-operation and Development, *National Accounts Main Aggregates, Vol. 1, 1960-1994*, Paris, 1996.
e. Organisation for Economic Co-operation and Development, *National Accounts Detailed Tables Vol. 2, 1981-1993*, Paris, 1995.
f. Statistics Canada, National Accounts and Environment Division.
g. United Nations, *Monthly Bulletin of Statistics*, UN Statistical Division, New York, 1992; and Statistics Canada.
h. United Nations, *Statistical Yearbook, 39th Edition*, Department of Economic and Social Information and Policy Analysis, Statistical Division, New York, 1994; and Statistics Canada.
i. World Bank, *Social Indicators of Development 1995*, The John Hopkins University Press, Baltimore,1995.
j. World Bank, *World Tables, 1995*, The John Hopkins University Press, Baltimore,1995.
k. World Resources Institute, *World Resources 1994-95: A Guide to the Global Environment*, The Oxford University Press, Oxford,1994.
l. World Resources Institute, *The 1994 Information Please Environmental Almanac*, The Houghton Mifflin Company, New York, 1994.
m. Statistics Canada, *Annual Demographic Statistics*, Cat. No. 91-213, Ottawa, 1994.
n. Statistics Canada, *Births and Deaths, 1993*, Cat. No. 84-210-XPB, Ottawa, 1996.

Table A1.2
Selected Water Quality Statistics, 1979-1993

Pollutant	River	Period				
		1979-1981	1982-1984	1985-1987	1988-1990	1991-1993
CANADA						
Dissolved oxygen (milligrams O_2 per litre)	Lake Ontario (mid-lake)	12.5	12.6	12.3	12.8	..
	Roseau River	7.9	8.0	8.3	..	6.9
	Saskatchewan River	10.8	10.6	10.4	10.3	9.9
	Slave River	..	..	..	..	11.2
Dissolved fluoride (milligrams F per litre)	Fraser River	0.1	--	0.1	0.1	..
	Mackenzie River	0.1	0.1	0.1	0.1	..
	Roseau River	0.1	0.1	0.1	0.2	..
	Saskatchewan River	0.1	0.1	0.1	0.2	..
	Slave River	0.1	0.1	0.1	0.1	..
Fecal coliform (number per 100 millilitres)	Roseau River	13.0	39.0	19.0	24.0	20.0
	Saskatchewan River	4.0	11.0	..	4.0	4.0
Total mercury (micrograms Hg per litre)	Fraser River	..	..	0.021	0.032	..
	Mackenzie River	0.037	..	..	..	..
	Roseau River	0.041	0.036	..	..	..
	Saskatchewan River	0.046	..	..	..	..
	Slave River	0.029	..	..	..	..
Nitrate + Nitrite (milligrams N per litre)	Fraser River	0.10	0.09	0.10	0.12	0.16
	Lake Ontario (mid-lake)	0.29	0.32	0.37	0.32	..
	Mackenzie River	0.08	0.08	..	0.07	0.07
	Roseau River	0.12	0.13	0.24	0.11	0.17
	Saskatchewan River	0.13	0.13	..	0.12	0.15
	Skeena River	..	..	0.09	..	..
	Slave River	0.04	0.08	0.05	0.05	0.07
Dissolved phosphorous (milligrams P per litre)	Mackenzie River	0.008	0.008	0.006	..	..
	Roseau River	0.035	0.043	..	..	..
	Saskatchewan River	0.010	0.017	0.011	..	..
	Slave River	0.016	0.021	..	..	..
Dissolved orthophosphate (milligrams P per litre)	Saskatchewan River	..	0.015	..	..	..
Particulate phosphorous (milligrams P per litre)	Mackenzie River	..	0.079	..	..	..
	Roseau River	..	0.027	..	..	..
	Saskatchewan River	..	0.046	0.060	..	..
	Slave River	..	0.274	..	..	..
Total phosphorous (milligrams P per litre)	Fraser River	0.014	0.094	0.068	0.046	..
	Lake Ontario (mid-lake)	0.013	0.014	0.011	0.010	..
	Mackenzie River	0.088	0.086	..	..	..
	Roseau River	0.062	0.068	0.075	0.067	..
	Saskatchewan River	..	0.057	..	0.043	..
	Slave River	0.213	0.348	0.219	0.111	..
Orthophosphate (milligrams P per litre)	Lake Ontario (mid-lake)	0.024	0.018	0.010	0.004	..
Suspended solids (milligrams per litre)	Fraser River	34	79	39	36	..
	Mackenzie River	97	74	..	33	35
	Roseau River	7	8	11	11	10
	Saskatchewan River	51	43	43	34	26
	Skeena River	..	..	33	..	..
	Slave River	153	406	41	24	34

Table A1.2
Selected Water Quality Statistics, 1979-1993 (continued)

Pollutant	River	Period 1979-1981	1982-1984	1985-1987	1988-1990	1991-1993
MEXICO						
Dissolved oxygen (milligrams O_2 per litre)	Rio Atoyac	..	4.3	1.8	1.1	..
	Rio Balsas	..	7.3	6.4	..	..
	Rio Blanco	..	4.4	3.6	3.7	..
	Rio Colorado	..	..	8.6	..	..
	Rio Lerma	1.9	1.0	1.3	..	..
	Rio Panuco	7.5	8.5	..	8.0	..
Fecal coliform (number per 100 millilitres)	Rio Atoyac	310 000	190 000	386 631	1 000 000	..
	Rio Balsas	14 000	40 000	99 986	..	..
	Rio Blanco	41 000	40 000	112 400	40 000	..
	Rio Colorado	674	344	246	69	..
	Rio Lerma	300 000	300 000	159 920	..	..
	Rio Panuco	1 280	161	1 028	..	..
Nitrate + Nitrite (milligrams N per litre)	Rio Atoyac	..	..	0.18	0.98	..
	Rio Blanco	..	..	2.13	1.28	..
	Rio Colorado	..	..	0.30	..	..
Dissolved orthophosphate (milligrams P per litre)	Rio Panuco	..	..	..	0.072	..
Total orthophosphate (milligrams P per litre)	Rio Balsas	..	..	0.248	..	..
	Rio Panuco	..	..	0.049	..	..
Total phosphorous (milligrams P per litre)	Rio Balsas	..	..	0.529	..	..
	Rio Panuco	..	..	0.060	..	..
Orthophosphate (milligrams PO_4 per litre)	Rio Atoyac	6.130	3.236	4.794	1.305	..
	Rio Balsas	0.836	0.070	0.356	..	..
	Rio Blanco	0.265	0.224	0.174	..	..
	Rio Colorado	0.129	..	0.072	..	..
	Rio Lerma	1.552	0.839	1.679	..	..
	Rio Panuco	0.065	..	..	..	..
Total phosphate (milligrams per litre)	Rio Atoyac	12.092	6.542	5.934	2.048	..
	Rio Balsas	1.226	0.698	0.729	0.419	..
	Rio Blanco	0.545	0.452	0.392	0.927	..
	Rio Colorado	0.216	0.211	0.147	0.033	..
	Rio Lerma	3.424	23.811	2.244	..	..
	Rio Panuco	0.080	..	..	..	..
Suspended solids (milligrams per litre)	Rio Atoyac	411	1 175	..	275	..
	Rio Balsas	4 641	3 221	2 123	..	..
	Rio Blanco	74	156	..	25	..
	Rio Colorado	59	37	..	21	..
	Rio Lerma	273	214	..	..	..
	Rio Panuco	337	55	217	77	..

Table A1.2
Selected Water Quality Statistics, 1979-1993 (concluded)

Pollutant	River	Period 1979-1981	1982-1984	1985-1987	1988-1990	1991-1993
UNITED STATES						
Dissolved oxygen (milligrams O_2 per litre)	Delaware River	11.4	11.0	12.0	8.4	10.1
	Hudson River	10.5	11.4	..	10.8	10.8
	Mississippi River	..	8.8	8.5	..	9.4
	Rio Grande	8.2	8.9	8.8	8.3	8.2
	Saint Lawrence River	10.7	11.4	9.1	10.3	11.4
Dissolved fluoride (milligrams F per litre)	Delaware River	0.1	0.1	..	0.1	0.1
	Hudson River	0.1	..	..	..	..
	Mississippi River	0.2	0.2	0.2	0.2	0.2
	Rio Grande	0.7	0.8	0.7	0.7	0.7
	Saint Lawrence River	0.1	0.2	0.2	0.2	..
Fecal coliform (number per 100 millilitres)	Delaware River	403	178	56	138	87
	Hudson River	1 102	1 070	..	..	519
	Mississippi River	457	1 145	2 989	..	590
	Rio Grande	3 830	2 567	1 404	2 136	1 418
	Saint Lawrence River	7	10	8	9	10
Dissolved mercury (micrograms Hg per litre)	Delaware River	..	0.23	..	..	..
	Rio Grande	0.11	..	..	..	..
Total mercury (micrograms Hg per litre)	Rio Grande	0.27	..	..	..	..
Nitrate + Nitrite (milligrams N per litre)	Delaware River	0.97	1.22	1.04	6.00	0.91
	Hudson River	0.63	0.65	..	0.55	0.48
	Mississippi River	1.40	..	1.48	1.19	1.63
	Rio Grande	0.14	..	..	..	0.26
	Saint Lawrence River	0.20	0.25	0.21	0.28	0.22
Total phosphorous (milligrams P per litre)	Delaware River	..	..	..	..	0.11
	Hudson River	..	..	..	..	0.05
	Mississippi River	..	..	..	..	0.18
	Rio Grande	..	..	..	..	0.11
	Saint Lawrence River	..	..	..	..	0.02
Dissolved phosphorous (milligrams P per litre)	Delaware River	..	..	..	..	0.05
	Hudson River	..	..	..	..	0.03
	Mississippi River	..	..	..	..	0.08
	Rio Grande	..	..	..	..	0.04

Notes:
The reader should note that data collection methods vary considerably from country to country. Caution should be used when interpreting the information. Although many countries adhere to United Nations guidelines for economic, demographic and social data collection, most have adapted these definitions and methods to better suit the local conditions. In addition, the collection of environmental data has often not reached the level of standardization that is found in these other fields.
Data are three-year averages.
Source:
Environment Canada, National Water Research Institute, Gems/Water Database.

Table A1.3

Concentrations of Selected Air Pollutants, 1980-1993

Pollutant	City	Number of stations	Base year value	Base year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
			µg/m³		index													
CANADA																		
SO_2	Canada	58-65	16	1985	163	132	132	99	115	100	100	81	100	100	100	75	81	..
	Montréal, Que.	7	14	1988	..	..	..	..	..	..	..	..	100	136	107	71	86	..
	Hamilton, Ont.	3	25	1988	..	..	..	..	..	..	..	..	100	124	96	96	88	..
	Vancouver, B.C.	4	26	1988	..	..	..	..	..	..	..	..	100	94	125	81	75	..
	Dorset, Ont.	1	3	1985	..	..	..	..	..	100	100	100	100	..	192	..	..	..
NO_2	Canada	34-47	41	1985	115	106	106	101	110	100	100	95	98	105	98	90	83	..
	Montréal, Que.	3	48	1988	..	..	..	..	..	..	..	..	100	108	108	98	73	..
	Hamilton, Ont.	2	46	1988	..	..	..	..	..	..	..	..	100	100	83	89	80	..
	Vancouver, B.C.	3	51	1988	..	..	..	..	..	..	..	..	100	94	92	94	92	..
	Dorset, Ont.	1	11	1985	..	..	..	..	166	100	66	34	34	..	35	..	..	..
Particulates	Canada	85	43	1985	156	136	120	111	107	100	100	112	102	102	91	91	84	..
	Montréal, Que.	6	46	1988	..	..	..	..	..	..	..	..	100	102	80	83	83	..
	Hamilton, Ont.	2	81	1988	..	..	..	..	..	..	..	..	100	99	89	83	70	..
	Vancouver, B.C.	8	35	1988	..	..	..	..	..	..	..	..	100	100	91	94	91	..
MEXICO																		
SO_2	Mexique, D.F.	5	163	1988	..	..	..	..	..	..	..	..	100	88	95	103	88	39
NO_2	Mexique, D.F.	5	228	1986	..	..	..	..	..	..	100	60	72	71	74	69	73	69
Particulates	Mexique, D.F.	5	619	1985	86	89	87	85	93	100	95	68	73	94	127	148	89	71
UNITED STATES																		
SO_2	United States	234	25	1985	120	113	107	104	107	100	99	96	98	95	88	87	81	80
	New York, NY	15	34	1985	111	113	105	98	105	100	92	94	100	95	84	83	75	67
	Los Angeles, CA	6	16	1985	116	115	116	103	121	100	87	77	76	57	46	46	43	40
	Steubenville, OH	2	52	1985	120	109	109	103	111	100	106	108	111	122	116	103	88	..
	Denver, CO	2	16	1985	142	158	132	153	126	100	99	107	106	91	91	102	109	99
	Dunn, CO	1	4	1985	69	82	133	100	92	100	95	77	79	82	79	77	79	87
NO_2	United States	83	46	1985	106	104	102	100	101	100	101	100	102	98	93	94	89	86
	Los Angeles, CA	12	86	1985	110	110	106	100	98	100	99	92	101	99	90	92	85	80
	New York, NY	3	53	1985	107	105	114	115	107	100	103	114	112	101	101	102	97	100
	Chicago, IL	1	67	1985	93	93	106	97	95	100	90	89	91	98	88	92	86	86
	Washington, D.C.	5	56	1985	97	97	94	95	98	100	102	97	92	85	93	90	87	88
	Mercer, CO	4	7	1985	99	103	91	86	87	100	120	96	91	90	96	93	97	97
Particulates	United States	241	34	1988	..	..	..	..	..	..	..	..	100	99	90	90	82	79
	Los Angeles, CA	13	58	1988	..	..	..	..	..	..	..	..	100	100	88	87	73	70
	New York, NY	14	31	1988	..	..	..	..	..	..	..	..	100	97	96	99	81	78
	Steubenville, OH	5	43	1988	..	..	..	..	..	..	..	..	100	104	92	97	88	..
	Denver, CO	6	35	1988	..	..	..	..	..	..	..	..	100	100	86	85	87	102
	Fargo Moorhead, ND	1	21	1988	..	..	..	..	..	..	..	..	100	98	101	89	100	84

Note:
The reader should note that the data collection methods vary considerably from country to country. Caution should be used when interpreting the information. Although many countries adhere to United Nations guidelines for economic, demographic and social data collection, most have adapted these definitions and methods to better suit the local conditions. In addition, the collection of environmental data has often not reached the level of standardization that is found in these other fields.

Source:
Organisation for Economic Co-operation and Development, *OECD Environmental Data, Compendium 1995*, Paris, 1995.

Annex 2: Environment and Natural Resource Statistics, Canada, Provinces and Territories

Table A2.1
Selected Environmental Quality Statistics, 1961-1995

	Source	1961	1966	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
AIR QUALITY															
Urban ground level[1]															
Average station exceedances for SO_2, NO_x and CO	a	..	..	..	..	..	..	..	..	..	..	..	9.8	6.6	10.3
Average station exceedances for ozone	a	..	..	..	..	..	..	..	..	..	..	..	25.4	23.7	23.8
Average station exceedances for particulates	a	..	..	..	..	..	..	..	..	..	..	..	8.2	8.0	5.8
Ozone layer[2] (Dobson units[3])															
Toronto	b	341	361	358	354	360	332	352	351	347	355	337	348	351	348
Edmonton	b	335	369	346	345	346	339	355	352	338	354	333	343	349	341
Resolute	b	361	395	382	398	408	387	382	366	371	371	380	377	375	371
Production of CFCs (kt)	b	..	..	..	..	..	..	..	..	..	..	..	17.3	14.0	15.2
Production of other ozone depleting substances (kt)	b	..	..	..	..	..	..	..	..	..	..	..	3.4	2.8	2.8
Air emissions															
Nitrogen dioxide (kt)	c	..	..	1 364	..	..	..	..	1 756	..	..	..	..	1 959	1 907
Sulphur dioxide (kt)	c	..	..	6 677	..	..	..	..	5 319	..	..	..	..	4 643	4 291
Carbon monoxide (kt)	c	..	..	10 057	..	..	..	..	10 594	..	..	..	..	10 273	..
Carbon dioxide from fossil fuel combustion (Mt)	d	194	265	334	342	363	376	379	381	396	390	394	412	414	402
Particulates (kt)	c	..	..	1 850	..	..	..	..	1 787	..	..	..	..	1 907	..
LAND															
Agricultural land use (million hectares)															
Cropland	e,f	25.3	27.9	..	27.8	..	..	..	..	28.3	..	..	..	..	30.9
Improved pasture	e,f	4.1	4.4	..	4.1	..	..	..	..	4.1	..	..	..	..	4.1
Summerfallow	e,f	11.4	10.4	..	10.8	..	..	..	..	10.9	..	..	..	..	9.7
Other land	e,f	1.0	1.0	..	1.0	..	..	..	..	0.9	..	..	..	..	1.4
Unimproved farmland	e,f	28.0	26.7	..	25.0	..	..	..	..	24.2	..	..	..	..	19.8
Total farmland	e,f	69.8	70.5	..	68.7	..	..	..	..	68.4	..	..	..	..	65.9
Proportion of Canada's land area in agriculture (%)	d	7.6	7.6	..	7.5	..	..	..	..	7.4	..	..	..	..	7.2
Grain crop production (all types) (thousand tonnes)	f	15 961	36 784	25 863	35 892	32 938	33 799	28 205	33 441	40 931	37 947	37 342	30 643	35 564	44 096
Total cattle inventory (thousands)[4]	f	11 934	12 879	12 826	13 271	13 644	14 128	15 101	15 260	14 384	13 619	12 807	12 650	12 764	12 764
Agricultural fertilizer use (thousand tonnes)															
Nitrogen	g	73	218	268	323	334	410	513	531	586	599	755	831	831	916
Phosphate	g	161	333	281	326	341	415	494	502	503	503	594	630	628	635
Potash	g	93	142	175	184	189	191	202	207	242	234	273	330	349	363
Total fertilizer sold (thousand tonnes)[5]	g	709	1 811	1 694	1 915	1 972	2 261	2 608	2 676	2 780	2 829	3 267	3 671	3 572	3 758
Value of agricultural pesticides applied (million $1986)	e	..	..	169	..	..	..	..	..	..	..	..	..	398	..
Forest land harvested (thousand ha)	l	..	..	..	..	..	..	..	680	704	735	823	876	873	795
Forest land defoliated by insects (thousand ha)[6]	l	..	..	..	..	..	..	..	..	64 658	68 494	55 178	48 646	41 690	43 781
Forest land burned, all causes (thousand ha)	l	..	..	1 059	1 695	780	1 184	849	1 032	1 814	1 438	289	2 701	4 777	5 393
Rural to urban land conversion (hectares)[7]	i	..	..	..	86 090	..	..	..	..	61 164	..	..	..	..	98 976
ATLANTIC FISH CATCH[8] (thousand tonnes)															
Groundfish	j	1 365	1 743	1 738	1 701	1 627	1 646	1 359	1 195	998	820	848	934	930	980
Pelagic	j	85	285	784	824	787	935	871	916	829	533	326	236	242	255
Salmon	j	2	4	4	5	4	5	4	5	4	4	3	3	4	4
Total finfish	j	1 452	2 032	2 526	2 530	2 418	2 586	2 234	2 116	1 831	1 357	1 177	1 173	1 176	1 239
ENERGY USE (petajoules)															
Coal	k,d	548	635	708	673	635	654	665	658	709	773	789	876	928	946
Oil	d	1 803	2 328	2 860	3 119	3 425	3 771	3 931	3 806	3 770	4 004	4 011	4 297	4 196	3 990
Natural gas	d	566	938	1 370	1 462	1 644	1 749	1 767	1 800	1 841	1 643	1 664	1 734	1 785	1 710
Nuclear	d,e	...	1	4	15	26	54	53	45	63	95	112	127	137	136
Total non-renewable energy	d	2 917	3 902	4 942	5 269	5 730	6 228	6 416	6 308	6 383	6 514	6 576	7 034	7 046	6 782
Hydroelectricity	d,e	364	463	555	564	615	641	709	699	729	725	766	761	797	826
Wood[9]	k	178	107	106	342	353	377	391	326	346	346	357	374	405	393
Total renewable energy	d	542	570	661	906	968	1 018	1 100	1 025	1 075	1 071	1 123	1 135	1 202	1 219
Total energy	d	3 459	4 472	5 603	6 175	6 698	7 246	7 516	7 333	7 458	7 586	7 698	8 169	8 248	8 001
Energy per capita (gigajoules per capita)	d	180	220	260	267	288	308	315	305	305	307	307	324	322	310
Energy per $ of real GDP (megajoules per 1986 $)	d	19.5	19.0	20.4	20.5	21.1	21.2	21.1	20.2	19.3	18.9	18.3	18.8	18.7	17.5

Notes:
1. This information provides a measure of the number of times the oxides, ozone or particulates exceeded maximum acceptable levels each year.
2. From 1961 to 1992 figures are averaged from six readings per year while 1994 figures are averaged from three readings.
3. Dobson unit: a unit measure used to estimate the thickness of the ozone layer. 100 Dobson units represents a quantity equivalent to a 1mm thick layer of ozone at sea level.
4. Changes in surveying dates and methods between 1975 and 1976 may cause some inconsistencies.
5. Total fertilizer sold includes all nutrients as well as fertilizer filler materials.
6. Any forested area may be defoliated by more than one insect. Therefore, there can be considerable overlap in the reported figures.
7. These figures represent rural to urban land use conversion over the preceding five years. Data were not collected after 1986.
8. Includes surveillance estimates of catches in the NAFO regulatory area and foreign catches made outside the 200-mile zone on straddling stocks and the Flemish Cap.
9. Includes spent pulping liquor, wood waste and residential firewood.

Sources:
a. Environment Canada, State of the Environment Directorate, *Technical Supplement to the Environmental Indicator Bulletin on Urban Air Quality*, Ottawa, 1994.
b. Environment Canada, State of the Environment Directorate, *Technical Supplement to the Environmental Indicator Bulletin on Stratospheric Ozone Depletion*, Ottawa, 1993.
c. Organisation for Economic Cooperation and Development, *OECD Environmental Data Compendium 1993*, Paris, 1993.
d. Statistics Canada, National Accounts and Environment Division.
e. Statistics Canada, *Human Activity and the Environment, 1994*, Catalogue No. 11-509E, Ottawa, 1994.
f. Statistics Canada, Agriculture Division.
g. Statistics Canada, *Fertilizer Trade*, Catalogue No. 46-207, Ottawa, various issues, and Agriculture Canada, Farm Policy Development Branch.
h. Natural Resources Canada, Canadian Forest Service, Canada's Forest Inventory 1981, 1986, 1991.
i. Environment Canada, State of Environment Directorate, *Technical Supplement to a Report on Canada's Progress Towards a National Set of Environmental Indicators*, Ottawa, 1991.
j. Department of Fisheries and Oceans Canada, Biological Sciences Directorate.
k. Environment Canada, State of the Environment Directorate, *Technical Supplement to the Environmental Indicator Bulletin on Energy Consumption*, Ottawa, 1994.
l. Natural Resources Canada, Canadian Forest Service.

Table A2.1

Selected Environmental Quality Statistics, 1961-1995 (concluded)

	Source	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
AIR QUALITY															
Urban ground level[1]															
Average station exceedances for SO_2, NO_x and CO	a	6.8	5.4	2.2	2.6	4.4	1.8	2.5	1.3	3.3	1.0	0.2	..	..	..
Average station exceedances for ozone	a	13.8	35.6	17.9	11.6	10.0	15.8	57.8	19.8	10.6	19.0	6.7	..	..	..
Average station exceedances for particulates	a	4.4	2.7	3.1	2.0	2.0	2.5	2.4	1.9	0.9	1.1	0.8	..	..	..
Ozone layer[2] (Dobson units[3])															
Toronto	b	344	333	339	340	336	345	342	339	330	338	333	319	333	..
Edmonton	b	359	334	340	335	334	339	330	334	332	337	328	311	326	..
Resolute	b	370	360	357	371	424	360	359	367	354	364	342	328	364	..
Production of CFCs (kt)	b	14.2	15.6	16.9	18.5	19.9	21.2	21.0	18.8	13.1	8.8	10.7	4.0	..	..
Production of other ozone depleting substances (kt)	b	3.2	3.7	4.7	4.6	5.0	6.6	6.6	5.4	4.1	3.5	2.5	1.0	..	..
Air emissions															
Nitrogen dioxide (kt)	c	1 897	1 884	1 871	1 984	1 934	2 037	2 117	2 120	1 999	1 976	1 939	..	..	..
Sulphur dioxide (kt)	c	3 612	3 625	3 955	3 692	3 627	3 762	3 838	3 695	3 323	3 306	3 030	..	..	..
Carbon monoxide (kt)	c	..	..	..	10 781	..	..	..	..	..	..	..	..	..	..
Carbon dioxide from fossil fuel combustion (Mt)	d	387	380	393	385	376	404	432	452	432	422	436	443	456	..
Particulates (kt)	c	..	..	..	1 709	..	..	..	..	1 855	..	..	..	..	..
LAND															
Agricultural land use (million hectares)															
Cropland	e,f	..	..	..	..	33.2	..	..	..	..	33.5	..	..	..	..
Improved pasture	e,f	..	..	..	..	3.6	..	..	..	..	4.1	..	..	..	..
Summerfallow	e,f	..	..	..	..	8.5	..	..	..	..	7.9	..	..	..	..
Other land	e,f	..	..	..	..	0.7	..	..	..	..	..	..	..	..	..
Unimproved farmland	e,f	..	..	..	..	21.8	..	..	..	..	..	..	..	..	..
Total farmland	e,f	..	..	..	..	67.8	..	..	..	..	67.8	..	..	..	..
Proportion of Canada's land area in agriculture (%)	d	..	..	..	..	7.4	..	..	..	..	7.4	..	..	..	..
Grain crop production (all types) (thousand tonnes)	f	46 728	41 415	35 933	41 209	50 870	44 477	30 250	41 881	49 530	46 314	44 605	45 802	46 805	49 517
Total cattle inventory (thousands)[4]	f	12 591	12 290	12 031	11 651	11 299	11 264	11 512	11 780	11 907	12 172	12 473	12 715	13 263	15 100
Agricultural fertilizer use (thousand tonnes)															
Nitrogen	g	966	1 002	1 157	1 254	1 221	1 145	1 188	1 160	1 196	1 158	1 253	1 306	1 406	1 448
Phosphate	g	636	652	713	724	695	626	634	614	614	578	592	637	641	628
Potash	g	344	338	377	400	370	370	404	356	360	338	310	328	328	310
Total fertilizer sold (thousand tonnes)[5]	g	3 742	3 842	4 243	4 435	4 300	4 069	4 241	4 048	4 105	3 922	4 071	4 218	4 536	4 566
Value of agricultural pesticides applied (million $1986)	e	..	..	..	694	..	..	..	..	705	..	..	..	..	..
Forest land harvested (thousand ha)	l	753	828	895	898	972	1 051	1 086	1 018	893	856	906	969	..	..
Forest land defoliated by insects (thousand ha)[6]	l	25 641	27 359	19 851	27 267	16 429	13 009	15 528	18 854	20 493	33 896	41 943	20 521	..	..
Forest land burned, all causes (thousand ha)	l	1 706	1 194	765	755	950	1 086	1 336	7 560	931	1 575	869	1 967	..	..
Rural to urban land conversion (hectares)[7]	i	..	..	..	..	55 210	..	..	..	..	..	..	..	..	..
ATLANTIC FISH CATCH[8] (thousand tonnes)															
Groundfish	j	1 032	949	983	1 062	1 157	1 120	1 031	1 026	998	886	659 p	455 p	192 p	..
Pelagic	j	217	231	270	302	379	412	493	423	516	331	286 p	258 p	203 p	..
Salmon	j	3	2	1	2	3	3	2	1	1	1	1 p	- p	- p	..
Total finfish	j	1 252	1 182	1 254	1 366	1 539	1 535	1 526	1 450	1 515	1 218	946 p	713 p	395 p	..
ENERGY USE (petajoules)															
Coal	k,d	1 002	1 048	1 167	1 122	1 040	1 118	1 200	1 198	1 077	1 104	1 137	1 044	1 086	..
Oil	d	3 332	3 183	3 170	3 077	3 038	3 155	3 339	3 402	3 463	3 249	3 175	3 462	3 604	..
Natural gas	d	1 718	1 754	1 880	2 361	2 317	2 358	2 593	2 790	2 676	2 705	2 863	2 886	3 010	..
Nuclear	d,e	130	166	177	206	242	262	281	271	248	288	274	319	366	..
Total non-renewable energy	d	6 182	6 151	6 394	6 766	6 637	6 893	7 413	7 660	7 465	7 346	7 449	7 711	8 066	..
Hydroelectricity	d,e	806	817	881	939	989	972	996	1 005	1 057	1 033	1 038	1 055	1 018	..
Wood[9]	k	421	459	391	473	498	503	503	483	473	485	491	493	537	..
Total renewable energy	d	1 227	1 276	1 272	1 412	1 487	1 475	1 499	1 488	1 530	1 518	1 529	1 548	1 555	..
Total energy	d	7 409	7 427	7 666	8 178	8 124	8 368	8 912	9 148	8 995	8 864	8 978	9 259	9 621	..
Energy per capita (gigajoules per capita)	d	280	277	288	304	297	304	321	325	314	306	308	314	329	..
Energy per $ of real GDP (megajoules per 1986 $)	d	16.6	16.1	15.9	16.1	15.4	15.4	15.7	15.7	15.4	15.5	15.6	15.9	16.1	..

Notes:
1. This information provides a measure of the number of times the oxides, ozone or particulates exceeded maximum acceptable levels each year.
2. From 1961 to 1992 figures are averaged from six readings per year while 1994 figures are averaged from three readings.
3. Dobson unit: a unit measure used to estimate the thickness of the ozone layer. 100 Dobson units represents a quantity equivalent to a 1mm thick layer of ozone at sea level.
4. Changes in surveying dates and methods between 1975 and 1976 may cause some inconsistencies.
5. Total fertilizer sold includes all nutrients as well as fertilizer filler materials.
6. Any forested area may be defoliated by more than one insect. Therefore, there can be considerable overlap in the reported figures.
7. These figures represent rural to urban land use conversion over the preceding five years. Data were not collected after 1986.
8. Includes surveillance estimates of catches in the NAFO regulatory area and foreign catches made outside the 200-mile zone on straddling stocks and the Flemish Cap.
9. Includes spent pulping liquor, wood waste and residential firewood.

Sources:
a. Environment Canada, State of the Environment Directorate, *Technical Supplement to the Environmental Indicator Bulletin on Urban Air Quality*, Ottawa, 1994.
b. Environment Canada, State of the Environment Directorate, *Technical Supplement to the Environmental Indicator Bulletin on Stratospheric Ozone Depletion*, Ottawa, 1993.
c. Organisation for Economic Cooperation and Development, *OECD Environmental Data Compendium 1993*, Paris, 1993.
d. Statistics Canada, National Accounts and Environment Division.
e. Statistics Canada, *Human Activity and the Environment, 1994*, Catalogue No. 11-509E, Ottawa, 1994.
f. Statistics Canada, Agriculture Division.
g. Statistics Canada, *Fertilizer Trade*, Catalogue No. 46-207, Ottawa, various issues, and Agriculture Canada, Farm Policy Development Branch.
h. Natural Resources Canada, Canadian Forest Service, Canada's Forest Inventory 1981, 1986, 1991.
i. Environment Canada, State of Environment Directorate, *Technical Supplement to a Report on Canada's Progress Towards a National Set of Environmental Indicators*, Ottawa, 1991.
j. Department of Fisheries and Oceans Canada, Biological Sciences Directorate.
k. Environment Canada, State of the Environment Directorate, *Technical Supplement to the Environmental Indicator Bulletin on Energy Consumption*, Ottawa, 1994.
l. Natural Resources Canada, Canadian Forest Service.

Table A2.2

Selected Statistics on Land by Province and Territory, 1986-1996

	Year	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Total area (km^2)		a	9 970 610	405 720	5 660	55 490	73 440	1 540 680	1 068 580	649 950	652 330	661 190	947 800	483 450	3 426 320
Water area (km^2)		a	755 180	34 030	--	2 650	1 350	183 890	177 390	101 590	81 630	16 800	18 070	4 480	133 300
Land area (km^2)		a	9 215 430	371 690	5 660	52 840	72 090	1 356 790	891 190	548 360	570 700	644 390	929 730	478 970	3 293 020
Area of farms (km^2)	1986	a	678 258	366	2 724	4 165	4 089	36 388	56 466	77 402	265 994	206 553	24 111	-	-
	1991	a	677 537	474	2 589	3 970	3 756	34 296	54 514	77 250	268 655	208 110	23 923	-	-
Forest land[1] (km^2)	1991	d	4 161 770	225 250	2 950	39 230	61 060	824 860	579 950	262 770	288 060	382 140	605 640	275 500	614 360
Other land (km^2)	1991	d	4 376 123	145 966	121	9 640	7 274	497 634	256 726	208 340	13 985	54 140	300 167	203 470	2 678 660
Land use distribution															
Area of farms (% of land area)	1986	a	7.4	0.0	0.0	0.0	0.0	0.4	0.6	0.8	2.9	2.2	0.3	0.0	0.0
	1991	a	7.4	0.0	0.0	0.0	0.0	0.4	0.6	0.8	2.9	2.3	0.3	0.0	0.0
Forest land (% of land area)	1991	d	45.2	2.4	0.0	0.4	0.7	9.0	6.3	2.9	3.1	4.1	6.6	3.0	6.7
Other land (% of land area)	1991	d	47.5	1.6	0.0	0.1	0.1	5.4	2.8	2.3	0.2	0.6	3.3	2.2	29.1
Use of farmland															
Cropland (km^2)	1986	a	331 812	49	1 565	1 095	1 295	17 444	34 580	45 193	133 258	91 625	5 708	-	-
	1991	a	335 078	63	1 541	1 062	1 222	16 385	34 117	47 610	134 589	92 920	5 568	-	-
Improved pasture (km^2)	1986	a	35 592	38	226	362	272	3 011	4 313	2 749	8 787	13 768	2 064	-	-
	1991	a	41 412	46	193	307	250	2 709	3 902	3 413	10 757	17 425	2 410	-	-
Summerfallow (km^2)	1986	a	84 990	4	26	39	43	318	803	5 092	56 583	21 270	812	-	-
	1991	a	79 209	1	10	12	16	147	637	2 970	57 128	17 714	575	-	-
Cropland tilled[2] (percent)	1991	b	80.9	97.7	99.4	98.9	98.7	99.1	98.2	94.1	70.2	84.0	90.6	-	-
Protected land															
Area (km^2)	1996	e	756 319	7 358	78	3 187	3 957	158 050	62 648	63 938	28 558	66 518	69 191	49 452	243 384
Proportion of total area (%)	1996	b	7.6	1.8	1.4	5.7	5.4	10.3	5.9	9.8	4.4	10.1	7.3	10.2	7.1
Road network															
Two-lane equivalent length[3] (km)	1990-91	f	874 155	12 290	4 935	25 779	20 670	119 321	167 500	84 965	193 923	173 473	62 158	5 238	3 903
Density (km/thousand km^2)	1990-91	f	95	33	872	488	287	88	188	155	340	269	67	11	1

Notes:
Figures may not add due to rounding.
See Chapter 7 for more detail on land cover and use statistics.
1. Values in 1986 include estimates of non-inventoried forest land.
2. Cropland in this definition excludes no-till and permanent cropland areas such as tree fruit orchards.
3. Canada figures includes 14 743 km under federal jurisdiction.

Sources:
a. Statistics Canada, *Canada Year Book 1994*, Catalogue No. 11-402E, Ottawa, 1994.
b. Statistics Canada, National Accounts and Environment Division.
c. Natural Resources Canada, *Canada's Forest Inventory, 1986*, Ottawa, 1987.
d. Natural Resources Canada, Canadian Forest Service, Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1993*, Ottawa, 1994.
e. Environment Canada, State of the Environment Directorate, *1996 State of the Environment Report*, Ottawa, 1996.
f. Transportation Association of Canada.

Table A2.3

Selected Statistics on Forestry by Province and Territory, 1986-1993

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon[1]	N.W.T.[1]
Total production[2] (million $)													
1986	5 775.5	95.4	0.6	147.2	365.3	1 096.4	1 015.0	53.7	91.4	114.2	2 796.2	--	..
1987	7 538.3	107.7	--	173.5	439.1	1 441.4	1 146.9	74.7	107.3	138.8	3 907.3	--	..
1988	8 061.9	122.1	1.5	203.9	546.8	1 540.3	1 201.0	68.7	119.1	152.7	4 105.5	0.6	..
1989	8 696.8	132.0	2.0	203.9	603.4	1 732.9	1 290.5	72.9	122.4	183.9	4 351.7	1.4	..
1990	8 113.8	135.9	2.6	196.2	557.9	1 649.3	1 168.4	78.9	102.6	203.4	4 017.7	0.9	..
1991	7 702.0	132.6	3.3	198.2	492.2	1 520.6	1 092.6	61.7	78.3	273.4	3 848.5	0.6	..
1992	8 358.5	128.4	1.7	220.1	475.1	1 580.7	1 188.3	76.3	99.3	293.9	4 294.3	0.6	..
1993	9 030.9	141.4	4.2	206.1	461.4	1 579.9	1 154.5	76.3	112.2	317.3	4 976.1	1.2	..
Total roundwood harvested (thousand cubic metres)													
1986	177 190	2 408	424	4 004	8 720	38 127	30 186	1 703	3 529	10 387	77 503	199	..
1987	191 685	2 524	479	4 789	7 869	39 503	29 692	1 887	3 666	10 496	90 591	188	..
1988	190 616	2 513	475	5 039	9 199	39 381	29 338	1 883	3 818	11 990	86 807	172	..
1989	188 254	2 535	416	4 772	9 281	36 192	29 642	1 848	3 685	12 293	87 414	176	..
1990[r]	162 952	2 876	448	4 639	8 824	30 524	25 420	1 563	2 758	11 911	73 861	82	46
1991[r]	161 538	2 680	452	4 348	8 643	29 595	23 829	1 278	2 957	12 926	74 706	79	46
1992[r]	170 304	2 821	510	4 248	9 205	31 171	24 286	1 598	3 081	14 594	78 579	162	49
1993[p]	175 799	3 131	534	4 585	8 959	34 604	25 432	1 539	4 433	14 183	78 004	193	203
Area harvested (hectares)													
1986	971 813	17 440	2 350	34 121	86 898	297 616	223 517	11 128	19 356	38 811	239 877	299	400
1987	1 050 849	18 940	2 725	42 266	88 976	329 300	228 464	12 362	25 742	40 248	259 982	1 172	672
1988	1 086 098	19 628	2 731	41 421	99 192	337 668	237 188	12 378	22 089	42 538	270 401	465	399
1989	1 017 818	19 449	2 421	36 733	90 114	342 231	230 308	12 205	22 281	41 688	218 384	1 554	450
1990[r]	892 869	22 100	2 317	39 310	80 109	253 325	238 213	10 349	16 538	48 387	181 530	366	325
1991[r]	856 403	18 661	2 091	37 566	91 916	236 725	199 720	8 518	17 522	49 213	193 654	350	467
1992[r]	905 755	18 391	2 550	33 932	103 335	248 491	190 676	11 414	18 471	55 852	221 599	639	405
1993[p]	968 584	20 640	2 976	42 780	100 650	311 623	206 000	10 993	19 456	44 565	207 748	634	519
Area burned - stocked timber-productive forest land[3] (hectares)													
1986	311 367	23 511	85	268	37 216	173 296	50 598	5 495	4 031	1 587	9 474	3 132	11
1987	306 516	10 622	16	312	895	27 849	5 461	84 266	129 332	24 295	22 308	1 150	10
1988	639 777	7	2	89	1 778	273 066	35 994	295 930	24 187	5 149	3 284	288	3
1989	3 877 394	2 651	2	159	280	2 108 206	4 990	1 539 180	137 404	2 994	11 089	70 439	..
1990	281 831	2 601	4	477	5 198	76 825	3 200	6 727	71 198	21 281	52 575	16 704	..
1991	375 130	9 576	23	1 022	2 732	101 305	5 025	55 266	118 850	2 222	16 658	61 227	-
1992[r]	265 727	1 015	8	805	4 668	24 298	10 331	187 890	12 768	1 006	17 212	3 785	-
1993	417 995	21	6	120	535	125 211	2 116	44 545	227 208	13 858	1 376	-	-
Area seeded and planted (hectares)													
1986	334 918	802	863	9 160	20 517	64 888	94 782	4 146	4 482	19 539	115 739	-	-
1987	430 456	5 604	1 092	9 880	18 916	92 437	101 468	5 721	3 110	23 226	169 002	-	-
1988	459 865	4 468	1 077	11 655	19 123	99 880	111 251	7 061	7 020	28 845	169 485	-	-
1989	476 440	4 691	744	9 760	20 272	103 230	118 256	8 264	6 106	30 807	174 310	-	-
1990[r]	510 828	3 548	833	11 255	22 148	108 388	107 861	6 282	6 012	35 253	209 168	..	80
1991[r]	513 784	2 891	1 032	8 198	19 529	108 095	120 627	8 041	6 545	39 363	199 422	..	41
1992[r]	466 914	3 531	1 161	7 502	16 526	98 892	96 258	7 142	6 403	44 520	184 922	..	57
1993[p]	451 965	2 790	1 227	5 213	13 089	86 048	101 684	5 659	6 679	39 166	190 176	174	60

Notes:
Figures may not add due to rounding.
One square kilometre contains 100 hectares.
1. Data for Northwest Territories included in data for Yukon when not available separately.
2. Total production is the value of shipments of the logging industry.
3. Canada total includes areas burned in National Parks.

Sources:
Statistics Canada, *Canadian Forestry Statistics,* Catalogue No. 25-202, Ottawa, various issues.
Natural Resources Canada, Canadian Forests Service, Canadian Council of Forest Ministers, *Compendium of Canadian Forestry Statistics 1994*, Ottawa, 1995.

Table A2.4

Nominal Catches and Landed Values of Fish by Species and Region, 1993 and 1994

	1993[p]						1994[p]					
	Atlantic coast		Pacific coast		**Canada**		Atlantic coast		Pacific coast		**Canada**	
Species	Quantity[1]	Value	Quantity[1]	Value	**Quantity[1]**	**Value**	Quantity[1]	Value	Quantity[1]	Value	**Quantity[1]**	**Value**
	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**	tonnes	thousand dollars	tonnes	thousand dollars	**tonnes**	**thousand dollars**
Groundfish												
Cod[2]	71 889	59 936	7 700	4 377	**79 589**	**64 313**	22 550	29 417	3 500	2 300	**26 050**	**31 717**
Haddock	13 131	20 997	-	-	**13 131**	**20 997**	6 955	13 965	-	-	**6 955**	**13 965**
Redfish	77 734	21 070	22 527	16 031	**100 261**	**37 101**	50 774	15 716	23 372	20 100	**74 146**	**35 816**
Halibut	1 482	6 979	5 688	27 000	**7 170**	**33 979**	1 206	7 654	5 326	33 618	**6 532**	**41 272**
Flatfishes	38 597	23 659	9 341	6 712	**47 938**	**30 371**	15 165	17 974	7 980	6 639	**23 145**	**24 613**
Turbot	18 909	16 153	3 932	1 002	**22 841**	**17 155**	10 964	14 279	4 000	1 000	**14 964**	**15 279**
Pollock	21 970	12 370	5 744	1 877	**27 714**	**14 247**	15 584	10 885	3 626	1 152	**19 210**	**12 037**
Hake[3]	35 388	22 146	62 509	8 664	**97 897**	**30 810**	14 656	9 041	109 546	15 467	**124 202**	**24 508**
Cusk	2 948	2 347	-	-	**2 948**	**2 347**	1 692	1 400	-	-	**1 692**	**1 400**
Catfish	1 003	283	-	-	**1 003**	**283**	485	183	-	-	**485**	**183**
Other	3 583	1 281	9 127	23 325	**12 710**	**24 606**	3 948	2 417	9 011	29 135	**12 959**	**31 552**
Total	**286 634**	**187 221**	**126 568**	**88 988**	**413 202**	**276 209**	**143 979**	**122 931**	**166 361**	**109 411**	**310 340**	**232 342**
Pelagic and other finfish												
Herring/sardines	194 126	24 572	40 669	67 999	**234 795**	**92 571**	205 562	27 328	40 218	80 000	**245 780**	**107 328**
Mackerel	26 124	7 208	-	-	**26 124**	**7 208**	19 961	6 797	2	2	**19 963**	**6 799**
Swordfish	..	..	..	..	**..**	**..**	1 675	14 050	-	-	**1 675**	**14 050**
Tuna	524	5 678	322	755	**846**	**6 433**	608	9 467	634	1 444	**1 242**	**10 911**
Alewife	5 680	1 306	-	-	**5 680**	**1 306**	5 825	1 624	-	-	**5 825**	**1 624**
Eel	393	1 650	-	-	**393**	**1 650**	568	2 333	-	-	**568**	**2 333**
Salmon	134	625	81 743	189 338	**81 877**	**189 963**	107	548	65 399	250 485	**65 506**	**251 033**
Skate	293	47	224	38	**517**	**85**	6 362	2 250	378	218	**6 740**	**2 468**
Smelt	889	923	1	3	**890**	**926**	1 363	1 751	3	8	**1 366**	**1 759**
Capelin	47 441	13 409	-	-	**47 441**	**13 409**	2 140	554	-	-	**2 140**	**554**
Other	5 427	18 739	886	797	**6 313**	**13 409**	5 133	5 153	986	1 044	**6 119**	**6 197**
Total	**281 031**	**74 157**	**123 845**	**258 930**	**404 876**	**326 960**	**249 305**	**71 856**	**107 619**	**333 201**	**356 924**	**405 057**
Shellfish												
Clams/quahaug	24 081	24 530	3 582	27 980	**27 663**	**52 510**	26 046	27 007	3 955	37 360	**30 001**	**64 367**
Oysters	621	1 193	5 250	4 200	**5 871**	**5 393**	2 630	4 604	5 000	4 400	**7 630**	**9 004**
Scallop	88 586	115 718	-	-	**88 586**	**115 718**	91 347	138 592	107	504	**91 454**	**139 096**
Squid	2 701	568	-	-	**2 701**	**568**	5 778	2 972	165	187	**5 943**	**3 158**
Mussels	..	..	..	..	**..**	**..**	6 118	6 496	-	-	**6 118**	**6 496**
Lobster	40 098	293 718	-	-	**40 098**	**293 718**	41 122	351 109	-	-	**41 122**	**351 109**
Shrimps	38 037	81 299	4 262	12 140	**42 299**	**93 439**	48 830	99 107	4 185	15 577	**53 015**	**114 684**
Crab	62 611	112 544	6 242	18 550	**68 853**	**131 094**	64 870	271 972	5 645	24 158	**70 515**	**296 129**
Other	3 295	5 025	7 454	10 615	**10 749**	**15 640**	3 555	5 462	7 096	11 624	**10 651**	**17 086**
Total	**260 030**	**634 595**	**26 790**	**73 485**	**286 820**	**708 080**	**290 295**	**907 320**	**26 151**	**93 808**	**316 446**	**1 001 128**
Miscellaneous items[4]	**17 931**	**6 271**	**200**	**1 060**	**18 131**	**7 331**	**32 379**	**14 488**	**277**	**17 201**	**32 656**	**31 689**
Total sea fisheries	**845 626**	**902 244**	**277 403**	**422 463**	**1 123 029**	**1 318 580**	**715 958**	**1 116 595**	**300 408**	**553 621**	**1 016 366**	**1 670 216**
Total inland fisheries	**...**	**...**	**...**	**...**	**36 757**	**69 754**	**...**	**...**	**...**	**...**	**..**	**..**
Grand total	**845 626**	**902 244**	**277 403**	**422 463**	**1 159 786**	**1 388 334**	**715 958**	**1 116 595**	**300 408**	**553 621**	**1 016 366**	**1 670 216**

Notes:

Figures may not add due to rounding.

1. Quantity in tonnes, live weight.
2. Pacific cod includes grey cod only.
3. Hake catches include over-the-side sales to foreign vessels.
4. Contains marine plants and lumpfish roe. May contain other miscellaneous items.

Source:

Department of Fisheries and Oceans Canada, Biological Sciences and Industry Development and Programs Directorate.

Table A2.5
Reserves of Crude Oil and Natural Gas by Province and Territory, December 31, 1986-1994

	Year	Canada	Eastern Canada	East coast offshore	Ont.	Man.	Sask.	Alta.	B.C.	Mainland territories	Mackenzie Delta/ Beaufort Sea	Arctic Islands
Crude oil (thousand cubic metres)												
	1986	**944 411**	2	83 000	904	10 522	106 296	632 743	18 500	27 460	64 950	34
	1987	**940 162**	2	83 000	794	10 485	106 146	631 315	17 013	26 358	64 950	99
	1988	**975 148**	5	133 000	1 311	8 838	112 838	611 518	17 934	24 610	64 950	144
	1989	**937 993**	5	138 600	1 324	8 349	111 909	582 531	18 490	22 734	53 950	101
	1990	**887 957**	5	138 600	1 414	8 351	116 896	530 205	17 566	20 893	53 950	77
	1991	**841 302**	5	138 600	1 323	7 806	110 336	489 959	17 662	21 609	53 950	52
	1992	**809 734**	5	138 020	1 224	7 144	119 515	452 143	17 911	19 748	53 950	74
	1993	**800 586**	5	137 017	1 169	6 534	131 213	435 003	17 549	17 979	53 950	167
	1994	**778 793**	5	135 695	2 046	6 477	135 283	409 543	19 431	16 249	53 950	114
Natural gas (million cubic metres)												
	1986	**2 745 510**	141	-	17 444	-	61 305	1 749 997	240 307	11 636	258 310	406 370
	1987	**2 692 783**	125	-	17 949	-	60 705	1 727 725	210 327	11 272	258 310	406 370
	1988	**2 670 545**	98	-	18 311	-	56 283	1 688 054	210 094	11 205	280 130	406 370
	1989	**2 732 449**	90	-	17 529	-	74 791	1 705 559	218 393	10 987	298 730	406 370
	1990	**2 725 390**	72	-	16 903	-	78 880	1 689 884	223 638	10 913	298 730	406 370
	1991	**2 710 869**	72	-	16 718	-	71 182	1 678 553	229 215	10 029	298 730	406 370
	1992	**2 671 554**	71	-	16 881	-	70 409	1 621 875	247 335	9 883	298 730	406 370
	1993	**2 232 256**	111	-	17 217	-	80 927	1 578 959	246 957	9 355	298 730	-[1]
	1994	**1 897 990**	111	-	13 415	-	85 301	1 547 640	242 227	9 297	-[2]	-[1]

Notes:
Figures may not add due to rounding.
1. Reserves of natural gas in the Arctic Islands are no longer considered as economically recoverable.
2. Reserves of natural gas in the Mackenzie Delta and Beaufort Sea are no longer considered as economically recoverable.
Source:
Canadian Petroleum Association, *Statistical Handbook*, Calgary, various issues.

Table A2.6
Quantity of Production of Crude Oil and Natural Gas by Province and Territory, 1986-1994

	Year	Canada	Eastern Canada	East coast offshore	Ont.	Man.	Sask.	Alta.	B.C.	Yukon[1]	N.W.T.[1]
Crude oil (thousand cubic metres)											
	1986	**69 226**	--	-	136	823	11 688	53 082	2 020	-	1 478
	1987	**71 823**	--	4	136	782	12 078	55 170	2 084	-	1 570
	1988	**74 495**	-	-	191	769	12 168	57 653	1 882	-	1 833
	1989	**70 977**	-	-	244	723	11 633	54 605	1 888	-	1 884
	1990	**70 179**	-	-	247	738	12 431	52 973	1 926	-	1 864
	1991	**69 362**	-	-	235	713	12 390	52 085	2 013	-	1 927
	1992	**71 898**	-	576	224	656	13 355	53 175	2 033	-	1 878
	1993	**75 233**	-	1 016	253	635	14 939	54 548	2 004	-	1 838
	1994	**78 382**	-	1 313	263	658	17 184	55 197	1 987	-	1 779
Natural gas (million cubic metres)											
	1986	**91 667**	1	-	504	-	2 204	80 303	8 374	-	282
	1987	**99 490**	1	-	508	-	2 751	86 259	9 724	-	249
	1988	**114 135**	-	-	509	-	4 156	98 577	10 687	-	205
	1989	**118 706**	-	-	492	-	5 506	99 747	12 788	-	171
	1990	**121 696**	-	-	449	-	6 552	102 748	11 800	-	147
	1991	**129 596**	-	-	428	-	7 172	106 851	14 712	-	434
	1992	**143 205**	-	-	427	-	7 030	118 895	16 134	506	213
	1993	**155 030**	-	-	411	-	7 372	129 129	17 399	491	228
	1994	**166 531**	-	-	429	-	8 157	138 265	19 025	470	185

Notes:
Figures may not add due to rounding.
1. From 1986 to 1991, production data for the Yukon and N.W.T. are reported together under the N.W.T.
Source:
Statistics Canada, *The Crude Petroleum and Natural Gas Industry*, Catalogue No. 26-213, Ottawa, various issues.

Table A2.7

Selected Metal Reserves by Province and Territory, December 31, 1986-1993

	Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Copper (thousand tonnes)														
	1986	**13 331**	-	-	62	330	623	6 260	492	5	-	5 560	-	-
	1987	**12 939**	-	-	62	311	806	6 103	475	5	-	5 177	-	-
	1988	**12 693**	-	-	34	302	838	5 866	515	5	-	5 133	-	-
	1989	**12 258**	-	-	21	471	844	5 514	519	2	-	4 889	-	-
	1990	**11 203**	-	-	11	375	775	5 050	538	-	-	4 454	-	-
	1991	**11 115**	-	-	-	238	1 601	4 695	422	3	-	4 156	-	-
	1992	**10 818**	-	-	-	234	1 503	4 960	421	-	-	3 699	-	-
	1993	**9 784**	-	-	-	230	930	4 735	425	-	-	3 466	-	-
Nickel (thousand tonnes)														
	1986	**6 704**	-	-	-	-	--	4 908	1 796	-	-	-	-	-
	1987	**6 605**	-	-	-	-	-	4 822	1 784	-	-	-	-	-
	1988	**6 279**	-	-	-	-	-	4 546	1 733	-	-	-	-	-
	1989	**6 132**	-	-	-	-	-	4 461	1 672	-	-	-	-	-
	1990	**5 792**	-	-	-	-	-	4 208	1 584	-	-	-	-	-
	1991	**5 691**	-	-	-	-	-	4 162	1 529	-	-	-	-	-
	1992	**5 605**	-	-	-	-	-	4 160	1 445	-	-	-	-	-
	1993	**5 409**	-	-	-	-	-	4 036	1 372	-	-	-	-	-
Lead (thousand tonnes)														
	1986	**7 167**	-	-	-	3 648	-	133	25	--	-	1 256	1 275	831
	1987	**6 694**	-	-	-	3 551	-	104	25	--	-	1 180	1 212	621
	1988	**6 969**	-	-	-	3 482	-	101	20	-	-	1 071	1 755	540
	1989	**6 941**	-	-	68	3 839	9	100	17	-	-	999	1 404	506
	1990	**6 317**	-	-	29	3 383	28	94	13	-	-	957	1 358	456
	1991	**4 954**	-	-	-	2 463	23	63	9	-	-	908	1 093	397
	1993	**4 348**	-	-	-	2 264	20	53	11	-	-	786	856	358
	1993	**4 152**	-	-	-	2 176	24	66	9	-	-	728	825	325
Zinc (thousand tonnes)														
	1986	**22 423**	58	-	104	8 964	987	3 972	641	1	-	2 516	1 958	3 222
	1987	**20 636**	95	-	104	8 736	897	3 454	612	1	-	2 435	1 765	2 538
	1988	**21 116**	36	-	60	8 575	836	3 265	1 016	2	-	2 270	2 816	2 239
	1989	**21 688**	16	-	160	9 704	1 414	2 999	1 084	1	-	1 934	2 250	2 126
	1990	**20 091**	-	-	76	8 700	1 224	2 689	1 145	-	-	1 942	2 419	1 897
	1991	**16 448**	-	-	-	6 156	1 732	2 213	887	4	-	1 889	1 957	1 609
	1992	**15 067**	-	-	-	5 738	1 710	1 819	938	-	-	1 835	1 502	1 524
	1993	**14 213**	-	-	-	5 566	1 097	1 973	969	-	-	1 810	1 451	1 348
Silver (tonnes)														
	1986	**26 694**	-	-	-	9 759	1 506	6 893	721	2	-	5 838	1 849	126
	1987	**25 648**	-	-	-	9 699	1 501	6 057	729	2	-	5 621	1 896	143
	1988	**26 959**	-	-	-	9 933	1 200	5 802	812	3	-	6 140	2 943	127
	1989	**26 790**	4	-	-	10 761	1 620	5 504	787	1	-	5 624	2 349	141
	1990	**23 227**	4	-	-	9 498	1 311	5 027	757	1	-	4 162	2 339	127
	1991	**19 069**	2	-	-	7 003	2 074	4 422	654	3	-	2 838	1 953	121
	1992	**16 300**	3	-	-	6 456	2 008	4 106	398	-	-	2 098	1 119	113
	1993	**15 667**	2	-	-	6 227	1 424	4 106	451	-	-	2 017	1 324	117
Gold (tonnes)														
	1986	**1 496**	43	-	-	72	229	882	40	2	-	163	7	57
	1987	**1 727**	41	-	-	59	297	998	58	1	-	167	13	91
	1988	**1 914**	38	-	2	74	373	1 017	50	7	-	172	40	142
	1989	**1 748**	41	-	1	69	352	951	40	4	-	124	29	136
	1990	**1 548**	39	-	-	59	343	812	34	13	-	117	26	105
	1991	**1 443**	27	-	-	46	342	766	29	14	-	103	24	95
	1992	**1 367**	27	-	-	42	319	746	29	2	-	88	18	97
	1993	**1 337**	23	-	-	40	268	761	37	5	-	72	18	113

Note:
Figures may not add due to rounding.
Source:
Natural Resources Canada, *Canadian Minerals Yearbook, Review and Outlook*, Ottawa, various issues.

Table A2.8

Production of Selected Metals by Province and Territory, 1986-1995

	Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Copper (tonnes)	1986	**698 527**	-	-	-	6 298	51 622	264 870	65 369	3 506	-	306 855	6	1
	1987	**794 149**	-	-	x	7 233	66 848	287 354	66 121	2 335	-	364 134	x	2
	1988	**758 478**	-	-	-	7 966	47 633	286 536	53 072	2 168	-	360 570	x	1
	1989	**704 432**	-	-	x	7 802	65 135	271 914	50 484	x	-	308 348	-	-
	1990	**771 433**	-	-	x	8 620	99 198	273 448	55 506	x	-	333 883	-	-
	1991	**780 362**	-	-	x	10 476	113 931	261 899	54 875	x	-	338 642	-	-
	1992	**761 694**	-	-	-	13 697	91 950	272 242	60 024	-	-	323 781	-	-
	1993	**709 650**	231	-	-	11 190	78 973	277 461	56 502	-	-	285 293	-	-
	1994	**590 784**	548	-	-	8 562	69 150	224 801	41 293	-	-	246 430	-	-
	1995p	**704 863**	2 414	-	-	13 617	110 000	250 587	46 754	-	-	281 492	-	-
Nickel (tonnes)	1986	**163 639**	-	-	-	-	-	121 851	41 788	-	-	-	-	-
	1987	**189 086**	-	-	-	-	-	130 171	58 915	-	-	-	-	-
	1988	**198 744**	-	-	-	-	-	128 558	70 186	-	-	-	-	-
	1989	**195 554**	-	-	-	-	-	130 632	64 922	-	-	-	-	-
	1990	**195 004**	-	-	-	-	-	128 828	66 176	-	-	-	-	-
	1991	**188 098**	-	-	-	-	-	125 790	62 309	-	-	-	-	-
	1992	**177 555**	-	-	-	-	-	118 860	58 695	-	-	-	-	-
	1993	**178 529**	-	-	-	-	-	125 833	52 696	-	-	-	-	-
	1994	**141 974**	-	-	-	-	-	106 852	35 122	-	-	-	-	-
	1995p	**166 842**	-	-	-	-	-	127 828	39 014	-	-	-	-	-
Lead (tonnes)	1986	**334 342**	-	-	-	66 590	-	6 288	590	-	-	91 947	35 091	133 836
	1987	**373 215**	-	-	x	66 485	-	6 092	x	-	-	57 078	x	131 744
	1988	**351 148**	-	-	-	74 543	-	2 485	457	-	-	105 103	117 058	51 502
	1989	**268 887**	-	-	-	65 180	-	1 074	1 365	-	-	67 006	94 529	39 734
	1990	**233 372**	-	-	x	56 244	-	x	1 755	-	-	19 312	104 181	46 588
	1991	**248 102**	-	-	x	51 957	-	x	2 286	-	-	63 385	93 912	35 388
	1992	**339 626**	-	-	834	80 885	-	-	1 487	-	-	81 591	135 688	39 141
	1993	**183 105**	-	-	-	72 108	-	-	1 933	-	-	52 030	27 857	29 178
	1994	**167 584**	-	-	-	76 019	-	-	422	-	-	57 017	-	34 126
	1995p	**203 050**	-	-	-	85 105	-	-	-	-	-	59 403	27 000	31 542
Zinc (tonnes)	1986	**988 173**	5 712	-	-	161 807	37 126	265 248	61 463	3 527	-	137 583	50 634	265 073
	1987	**1 157 936**	7 643	-	-	180 298	91 139	294 309	63 551	1 764	-	114 117	147 045	258 070
	1988	**1 370 000**	31 817	-	x	261 089	82 031	326 698	53 746	x	-	142 833	143 939	325 321
	1989	**1 272 854**	27 362	-	x	201 550	100 638	266 158	72 096	x	-	119 376	154 709	329 001
	1990	**1 179 372**	16 463	-	x	233 933	120 599	276 110	77 507	x	-	59 346	168 846	218 241
	1991	**1 083 008**	-	-	x	209 790	117 404	213 599	88 486	x	-	125 980	149 487	173 154
	1992	**1 195 736**	-	-	582	301 020	107 466	190 523	89 211	-	-	133 149	202 304	171 481
	1993	**990 727**	-	-	-	303 985	131 852	179 049	89 658	-	-	107 457	35 204	143 521
	1994	**976 309**	-	-	-	291 796	139 898	163 658	93 607	-	-	115 510	-	171 840
	1995p	**1 093 541**	-	-	-	334 853	163 000	157 118	79 680	-	-	138 924	41 000	178 965
Silver (tonnes)	1986	**1 088**	-	-	-	163	62	348	37	3	--	380	73	22
	1987	**1 475**	-	-	--	182	163	441	41	2	--	401	133	13
	1988	**1 443**	x	-	x	203	140	434	32	x	-	447	159	26
	1989	**1 312**	x	-	x	191	148	349	36	x	-	498	71	18
	1990	**1 381**	x	-	x	145	164	330	41	x	-	598	84	19
	1991	**1 261**	x	-	x	158	164	294	43	x	-	497	87	17
	1992	**1 169**	x	-	--	254	143	248	40	x	-	345	124	16
	1993	**879**	x	-	-	223	143	232	38	x	-	201	30	11
	1994	**740**	x	-	-	226	139	196	34	x	-	127	1	17
	1995p	**1 195**	x	-	-	283	164	245	35	x	-	448	1	18
Gold (kilograms)	1986	**102 899**	-	-	-	374	28 342	46 279	2 555	14	36	9 249	3 547	12 503
	1987	**115 818**	x	-	x	420	29 543	52 917	3 697	1 048	43	11 224	4 674	11 740
	1988	**134 813**	x	-	x	393	33 538	62 463	4 469	1 480	27	13 067	5 052	11 880
	1989	**159 494**	x	-	x	359	36 966	78 675	4 056	2 829	25	15 635	5 652	12 208
	1990	**167 373**	x	-	x	x	40 675	79 968	2 680	3 374	32	16 105	4 639	15 557
	1991	**175 282**	x	-	-	x	51 923	77 170	2 921	2 899	34	17 487	3 865	16 752
	1992	**160 351**	x	-	-	490	44 589	74 836	3 106	x	34	16 773	3 737	13 518
	1993	**153 129**	x	-	-	361	41 843	72 441	3 001	x	65	13 865	3 538	13 205
	1994	**146 428**	x	-	-	365	40 932	69 155	2 608	x	34	12 191	3 345	13 140
	1995p	**149 026**	x	-	-	401	39 011	63 200	3 529	x	21	19 168	4 583	13 758

Note:
Figures may not add due to rounding.
Sources:
Statistics Canada, *General Review of the Mineral Industries, Mines, Quarries and Oil Wells*, Catalogue No. 26-201, Ottawa, various issues.
Statistics Canada, *Canada's Mineral Production, Preliminary Estimates*, Catalogue No. 26-202, Ottawa, various issues.

Table A2.9

Value of Mineral Production, 1986-1995

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	million dollars												
1986	**32 446**	817	2	367	502	2 191	4 825	764	2 525	16 331	3 160	176	788
1987	**36 361**	743	3	407	624	2 780	5 652	1 000	3 151	17 080	3 615	437	870
1988	**36 955**	865	2	446	911	2 712	6 895	1 627	3 043	15 062	3 943	492	957
1989	**39 333**	897	2	442	859	2 878	7 308	1 668	3 017	16 456	4 123	534	1 149
1990	**40 778**	866	3	459	878	3 037	6 446	1 311	3 183	19 110	3 954	542	988
1991	**35 190**	772	3	460	671	2 930	5 101	1 125	2 863	16 373	3 840	349	703
1992	**35 414**	706	2	523	910	2 694	4 776	1 082	3 158	16 885	3 500	496	681
1993	**36 564**	699	1	558	772	2 692	4 535	862	3 238	18 925	3 538	140	603
1994	**41 151**	837	1	610	862	2 956	4 921	820	4 225	21 085	4 066	86	680
1995p	**43 368**	906	1	566	1 002	3 082	5 833	1 052	4 634	20 830	4 523	185	753

Notes:
Figures may not add due to rounding.
Figures include the shipments of fuels, metals and structural materials of all establishments in Canada, regardless of their industrial classification.
Source:
Statistics Canada, *Canada's Mineral Production, Preliminary Estimates*, Catalogue No. 26-202, Ottawa, various issues.

Table A2.10

Selected Statistics on Energy by Province and Territory, 1986-1994

	Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon and N.W.T.
Production[1] (petajoules)													
	1986	**9 736.4**	141.0	-	82.7	44.7	535.5	410.3	117.7	693.3	6 486.5	1 152.0	72.7
	1987	**10 250.4**	136.1	-	83.6	41.2	566.4	400.3	99.8	732.0	6 852.5	1 262.6	75.9
	1988	**11 175.4**	143.0	-	101.9	43.6	537.8	421.4	85.2	820.7	7 577.3	1 359.5	85.0
	1989	**11 349.7**	118.1	-	103.6	41.6	518.0	424.1	94.0	845.9	7 637.6	1 482.0	84.7
	1990	**11 392.6**	125.0	-	101.6	46.7	482.4	402.2	100.1	901.1	7 669.7	1 478.7	85.2
	1991	**11 789.0**	127.5	-	121.8	43.8	512.9	436.6	108.8	887.3	7 869.0	1 588.6	92.6
	1992	**12 217.5**	125.6	-	131.1	39.0	527.7	421.6	120.6	969.2	8 388.3	1 394.1	100.3
	1993	**12 995.2**	141.2	-	107.2	40.7	557.5	461.6	121.4	1 021.1	8 893.2	1 553.3	98.0
	1994	**13 890.2**	135.2	-	103.8	37.8	587.9	499.3	127.1	1 166.0	9 470.1	1 666.2	96.8
Total domestic consumption[1,2,3] (petajoules)													
	1986	**7 844.6**	129.7	17.5	221.6	175.7	1 421.5	2 700.6	240.7	408.0	1 769.4	725.6	34.2
	1987	**8 070.2**	137.8	19.2	227.8	190.1	1 444.4	2 771.4	234.4	420.7	1 824.8	768.2	31.3
	1988	**8 585.6**	143.2	20.5	236.5	214.6	1 540.1	2 919.7	260.0	454.7	1 943.3	821.1	31.9
	1989	**8 947.0**	155.6	22.2	243.4	234.4	1 574.4	3 033.7	260.6	460.0	2 053.6	877.9	31.2
	1990	**8 590.8**	156.1	22.5	243.2	225.6	1 521.4	2 785.3	257.5	457.3	2 019.2	871.1	31.6
	1991	**8 515.6**	145.7	22.1	236.1	221.6	1 473.5	2 788.0	255.8	443.9	2 042.2	855.6	31.0
	1992	**8 756.7**	142.8	21.9	243.4	228.3	1 523.8	2 859.1	257.8	513.9	2 084.2	849.1	32.5
	1993	**8 830.5**	142.8	22.4	242.3	223.7	1 555.5	2 828.4	263.1	520.0	2 102.1	897.1	33.0
	1994	**9 056.7**	126.9	22.1	235.5	232.3	1 578.2	2 838.2	266.4	563.5	2 235.2	920.5	37.9
Consumption per capita (gigajoules)													
	1986	**299.4**	224.4	135.9	248.4	241.4	211.1	285.0	220.0	395.0	725.6	240.2	426.4
	1987	**304.0**	239.0	148.8	254.2	260.2	212.2	286.2	213.0	405.9	746.8	250.7	383.1
	1988	**319.2**	248.5	158.1	262.7	292.7	224.5	295.4	235.4	440.7	789.0	262.5	383.4
	1989	**326.8**	269.5	170.0	268.4	317.6	226.6	298.9	235.6	449.7	820.0	273.6	367.5
	1990	**309.1**	269.6	171.8	266.5	303.6	216.7	269.3	232.3	452.4	789.9	264.0	361.6
	1991	**302.8**	251.1	169.0	257.2	296.1	208.1	266.2	229.9	441.1	785.1	253.2	342.9
	1992	**306.8**	244.6	166.4	263.1	303.1	213.0	268.6	230.5	509.6	786.8	244.1	349.8
	1993	**305.1**	244.3	168.2	260.3	296.0	215.2	261.4	233.9	514.1	781.9	251.0	350.7
	1994	**309.6**	218.2	164.2	251.8	306.3	216.7	259.6	235.5	555.9	822.1	251.0	401.9

Notes:
1. Total for Canada is the sum of all provinces and territories.
2. Domestic consumption data are equivalent to gross availability data in Statistics Canada Catalogue No. 57-003.
3. Includes consumption of energy commodities for non-energy purposes.
Source:
Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003, Ottawa, various issues.

Table A2.11

Federal Government Environmental Protection Expenditures, 1986-1994

	1986	1987	1988	1989	1990	1991	1992	1993[e]	1994[e]
	thousand dollars								
Pollution abatement and control									
Sewage collection and disposal	-	-	-	-	-	-	150	275	-
Pollution control	61 983	67 297	87 142	113 085	118 855	20 221	4 329	1 004	5 870
Other environmental services	383 744	430 794	442 869	497 185	571 471	682 955	709 679	749 906	929 389
Total[1]	**445 727**	**498 091**	**530 011**	**610 270**	**690 326**	**703 176**	**714 158**	**751 185**	**935 259**
Natural resource conservation and development									
Agriculture	3 238 420	4 720 870	3 614 210	3 011 500	2 592 670	4 622 130	3 237 910	2 881 500	2 436 520
Fish and game	388 334	328 401	393 464	402 070	470 382	483 973	693 646	692 158	573 942
Forests	224 701	660 250	311 776	284 463	215 421	206 653	236 048	237 655	225 869
Mines, oil and gas	1 094 980	708 981	767 246	365 551	383 426	325 310	321 573	497 388	568 992
Other resource conservation and development	702 999	650 481	707 769	760 003	725 538	623 016	620 308	591 718	522 337
Total	**5 649 440**	**7 068 990**	**5 794 460**	**4 823 590**	**4 387 440**	**6 261 080**	**5 109 490**	**4 900 420**	**4 327 660**

Notes:
Figures may not add due to rounding.
Includes transfer payments to other levels of government.
1. There are no federal government expenditures on waste collection and disposal.
Source:
Statistics Canada, Public Institutions Division.

Table A2.12

Provincial and Territorial Government Environmental Protection Expenditures, 1988-1992

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	thousand dollars												
Pollution abatement and control													
Sewage collection and disposal[1]													
1988	77 526	-	2 018	-	9 663	-	-	3 594	-	-	61 156	-	1 094
1989	72 412	-	-	720	9 554	-	-	-	-	-	59 729	2 409	-
1990[r]	75 327	-	-	127	9 367	-	-	-	95	-	63 557	2 181	-
1991[r]	100 597	-	-	92	8 191	-	-	-	64	-	89 873	2 377	-
1992	97 741	-	933	47	6 730	-	-	-	49	-	87 715	2 268	-
Waste collection and disposal													
1988	54 022	330	2 098	2 878	3 899	-	27 488	2 039	-	262	15 028	-	-
1989	114 495	163	2 150	8 817	4 579	-	36 648	5 481	-	31 029	25 425	202	-
1990[r]	121 947	296	2 268	12 546	5 850	-	50 234	5 415	-	38 515	6 667	158	-
1991[r]	156 545	261	3 170	12 672	5 907	-	73 066	6 493	8	40 108	14 657	202	-
1992	161 330	361	3 710	7 483	8 483	-	80 391	6 659	-	42 575	11 446	223	-
Other pollution control													
1988	226 639	2 754	128	-	9 320	23 766	134 829	263	4 009	47 997	2 885	-	689
1989	280 066	3 679	113	4 601	13 802	19 820	188 239	393	4 314	40 973	3 437	32	662
1990	296 300	2 559	176	5 312	13 834	-	202 993	399	29 465	40 754	11	8	789
1991	341 901	2 956	348	6 103	18 420	-	240 212	746	29 730	42 626	-	-	759
1992	295 129	3 014	286	2 248	16 910	-	220 643	393	4 579	44 667	1 684	-	705
Other environmental services													
1988	164 641	-	1 644	3 222	1 247	56 377	4 269	8 586	67 188	21 142	-	-	966
1989	202 524	1 525	2 585	15 722	1 840	74 925	4 530	8 537	71 500	7 813	12 936	500	111
1990[r]	373 895	16	3 117	18 029	6 045	147 799	12 813	9 351	74 464	9 410	92 408	444	-
1991[r]	451 019	22	3 012	18 437	17 627	157 476	12 430	10 100	121 699	11 500	98 067	589	62
1992	382 309	1 799	2 277	21 115	12 142	170 805	14 221	14 203	43 859	7 397	93 758	722	10
Total pollution abatement and control													
1988	522 828	3 083	5 887	6 101	24 129	80 143	166 586	14 482	71 197	69 401	79 069	-	2 748
1989	669 496	5 367	4 848	29 861	29 776	94 745	229 416	14 410	75 814	79 815	101 527	3 143	774
1990[r]	867 469	2 871	5 561	36 014	35 096	147 799	266 040	15 165	104 023	88 679	162 642	2 790	789
1991[r]	1 050 062	3 239	6 530	37 304	50 145	157 476	325 708	17 339	151 500	94 234	202 597	3 168	821
1992	936 508	5 174	7 206	30 893	44 264	170 805	315 255	21 255	48 486	94 639	194 604	3 212	715

Table A2.12

Provincial and Territorial Government Environmental Protection Expenditures, 1988-1992 (concluded)

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
						thousand dollars							
Natural resource conservation and development													
Agriculture													
1988	2 726 916	16 943	31 592	42 838	25 308	654 287	340 495	242 983	636 169	636 311	99 634	346	10
1989	2 834 386	18 629	34 309	40 853	30 577	638 860	329 100	278 030	611 185	755 443	97 062	326	11
1990[r]	2 895 463	15 921	33 580	42 658	35 308	717 880	385 949	177 629	656 309	723 411	106 453	347	18
1991[r]	4 146 636	13 101	42 660	39 741	37 910	835 784	393 517	473 086	1 174 851	1 043 009	92 449	485	42
1992	3 850 594	14 400	36 509	40 360	46 520	840 706	484 498	287 978	851 669	1 175 665	71 708	580	-
Fish and game													
1988	302 864	43 445	3 313	10 713	14 830	87 862	63 249	6 797	5 593	25 668	28 889	6 008	6 496
1989	342 942	50 158	3 363	8 562	27 608	95 092	70 067	10 403	6 876	27 198	29 529	6 462	7 624
1990[r]	346 447	44 750	3 742	6 903	23 905	111 413	77 668	9 686	9 621	28 907	16 092	5 814	7 943
1991[r]	336 311	32 444	4 066	7 628	20 956	99 392	85 151	8 538	10 819	31 457	21 852	5 796	8 212
1992	348 585	39 960	3 836	7 180	23 108	104 159	75 375	11 149	10 836	33 468	22 805	5 923	10 787
Forests													
1988	1 247 665	25 560	5 120	42 272	26 773	288 803	284 927	13 670	11 748	113 933	416 771	10	18 079
1989	1 394 897	29 767	5 739	80 212	21 765	292 842	266 760	15 699	69 916	111 643	468 092	788	31 674
1990[r]	1 416 206	31 032	6 603	51 736	26 445	298 156	286 626	19 589	50 442	140 452	481 048	875	23 202
1991[r]	1 485 726	26 602	6 722	50 064	30 629	310 038	293 912	17 834	81 156	117 001	524 565	848	26 356
1992	1 352 564	26 794	7 095	48 338	28 077	295 670	225 904	14 754	32 616	115 320	533 811	1 455	22 729
Mines, oil and gas													
1988	977 089	12 456	-	14 436	3 483	79 996	36 437	10 753	17 268	704 543	54 875	1 690	41 153
1989	1 340 073	13 385	-	9 741	3 229	76 756	41 753	10 203	379 331	707 789	48 868	3 037	45 983
1990[r]	982 137	18 030	-	10 640	3 886	81 812	41 592	9 782	126 073	603 688	37 330	1 271	48 031
1991[r]	1 138 269	40 810	-	11 567	2 871	78 486	41 690	10 950	316 613	531 617	53 027	1 331	49 308
1992	676 355	47 136	-	10 787	2 751	59 719	37 414	8 280	17 671	432 216	7 515	2 617	50 250
Other resource conservation and development													
1988	837 672	4 470	5 101	4 834	28 103	76 748	212 819	52 283	22 579	366 462	45 786	9 101	9 386
1989	860 072	3 711	6 979	5 454	35 271	80 178	224 993	74 531	26 831	269 099	110 895	5 568	16 562
1990[r]	760 292	4 540	6 013	5 053	33 160	78 907	263 169	45 359	22 768	212 998	61 890	7 013	19 422
1991[r]	791 669	4 043	5 441	9 369	29 465	65 955	312 277	28 114	22 042	213 629	74 132	6 534	20 668
1992	845 821	4 391	5 630	10 922	30 883	79 761	329 424	22 428	22 323	230 147	84 799	8 095	17 018
Total natural resource conservation and development													
1988	6 092 206	102 874	45 126	115 093	98 496	1 187 696	937 927	326 485	693 357	1 846 917	645 955	17 156	75 124
1989	6 772 370	115 650	50 390	144 823	118 450	1 183 728	932 672	388 865	1 094 139	1 871 171	754 447	16 180	101 855
1990[r]	6 400 545	114 273	49 938	116 991	122 704	1 288 168	1 055 004	262 045	865 213	1 709 458	702 814	15 321	98 616
1991[r]	7 898 611	117 000	58 889	118 368	121 832	1 389 655	1 126 547	538 522	1 605 480	1 936 712	766 027	14 994	104 586
1992	7 073 919	132 681	53 069	117 587	131 339	1 380 014	1 152 616	344 589	935 116	1 986 817	720 637	18 670	100 784
Parks													
1988	192 326	7 207	3 040	4 652	8 905	29 730	51 609	17 516	3 749	35 820	30 086	11	-
1989	227 059	6 458	3 293	15 289	9 575	30 048	57 660	17 157	16 402	33 074	37 243	861	-
1990[r]	225 894	6 442	3 663	7 186	10 053	31 707	66 408	18 278	17 072	33 020	31 500	565	-
1991[r]	204 653	6 644	3 654	6 838	9 450	32 569	57 154	16 374	15 449	27 559	28 550	412	-
1992	212 048	6 607	4 903	7 156	7 067	36 496	51 421	16 591	14 494	30 953	34 540	1 820	-

Notes:

Figures may not add due to rounding.

Fiscal years. Provincial and territorial government expenditures include intergovernmental transfer payments.

1. Some provinces and territories may report their sewage expenditures under water supply expenditures; these are considered as health protection expenditures and are therefore excluded. As an example, provincial government expenditures on water supply in 1992 were equal to $61 million in Newfoundland, $420 million in Quebec, $325 million in Ontario and $98.6 million in Alberta.

Source:

Statistics Canada, Public Institutions Division.

Table A2.13

Local Government Environmental Protection Expenditures, 1986-1994

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
	thousand dollars												
Pollution abatement and control													
Sewage collection and disposal													
1986	1 138 023	15 870	1 861	19 523	27 222	298 598	448 513	55 779	34 313	116 101	114 158	1 234	4 851
1987	1 208 602	19 216	1 797	25 389	31 212	287 120	476 460	39 115	35 169	130 956	152 517	1 078	8 573
1988	1 413 609	19 426	1 796	38 941	30 740	377 887	597 643	40 072	36 301	118 368	142 171	1 483	8 781
1989	1 734 756	19 028	1 945	31 176	30 702	531 371	723 837	49 106	41 358	138 229	154 934	1 061	12 009
1990	2 001 997	24 951	2 165	38 281	40 240	659 991	778 073	52 055	42 458	161 963	185 334	2 074	14 412
1991	1 954 272	19 420	2 580	63 118	42 898	537 628	838 006	55 495	37 362	146 430	192 799	4 216	14 320
1992p	1 899 753	18 450	2 558	40 592	40 963	471 149	826 209	89 248	37 129	139 037	213 709	6 105	14 604
1993p	1 869 010	19 996	2 127	72 645	45 536	433 920	750 029	61 193	43 356	188 897	227 954	5 549	17 808
1994[1]	2 357 364	11 959	1 972	87 295	45 805	699 218	835 099	58 384	97 687	178 087	315 847	9 490	16 521
Waste collection and disposal													
1986	627 753	12 110	549	17 372	6 514	143 005	267 841	19 445	16 066	47 835	93 584	799	2 633
1987	714 493	11 264	480	46 967	8 229	154 344	297 685	21 613	20 583	50 148	99 156	488	3 536
1988	817 079	10 576	497	21 941	9 824	178 308	391 866	24 526	17 841	53 813	103 199	625	4 063
1989	935 818	11 915	581	24 059	12 156	195 986	462 601	26 080	16 766	58 925	122 472	580	3 697
1990	1 125 905	12 044	612	31 928	13 305	223 016	584 145	25 682	17 595	66 592	146 467	640	3 879
1991	1 228 222	14 183	667	41 172	14 825	267 306	607 933	26 043	17 993	72 961	160 562	684	3 893
1992p	1 274 745	13 405	882	41 401	15 258	292 196	606 829	31 123	20 787	81 615	166 224	831	4 194
1993p	1 228 072	12 300	825	40 843	16 066	300 507	546 422	30 220	19 761	80 626	172 373	883	7 246
1994[1]	1 355 882	12 379	928	52 737	16 130	334 091	609 580	34 156	19 555	90 494	180 227	948	4 657
Other environmental services[2]													
1986	76 909	5	-	200	-	33 978	39 960	471	58	163	2 058	-	16
1987	87 911	14	139	60	514	35 427	48 508	514	124	264	2 331	-	16
1988	75 200	14	151	107	404	32 988	37 769	676	193	273	2 614	-	11
1989	82 615	11	160	225	15	31 674	45 901	668	225	204	3 514	-	18
1990	82 331	6	176	286	1 854	32 024	43 182	733	274	-	3 695	-	101
1991	80 949	4	183	1 332	1 844	18 387	54 307	884	205	-	3 742	1	60
1992p	84 166	4	193	447	1 881	14 775	61 624	764	307	-	4 111	-	60
1993p	86 396	4	189	467	1 972	24 852	53 559	755	301	-	4 237	-	60
1994[1]	91 560	4	189	425	1 998	34 799	48 603	754	300	-	4 428	-	60
Total pollution abatement and control													
1986	1 842 685	27 985	2 410	37 095	33 736	475 581	756 314	75 695	50 437	164 099	209 800	2 033	7 500
1987	2 011 006	30 494	2 416	72 416	39 955	476 891	822 653	61 242	55 876	181 368	254 004	1 566	12 125
1988	2 305 888	30 016	2 444	60 989	40 968	589 183	1 027 278	65 274	54 335	172 454	247 984	2 108	12 855
1989	2 753 189	30 954	2 686	55 460	42 873	759 031	1 232 339	75 854	58 349	197 358	280 920	1 641	15 724
1990	3 210 233	37 001	2 953	70 495	55 399	915 031	1 405 400	78 470	60 327	228 555	335 496	2 714	18 392
1991	3 263 443	33 607	3 430	105 622	59 567	823 321	1 500 246	82 422	55 560	219 391	357 103	4 901	18 273
1992p	3 258 664	31 859	3 633	82 440	58 102	778 120	1 494 662	121 135	58 223	220 652	384 044	6 936	18 858
1993p	3 183 478	32 300	3 141	113 955	63 574	759 279	1 350 010	92 168	63 418	269 523	404 564	6 432	25 114
1994[1]	3 804 806	24 342	3 089	140 457	63 933	1 068 108	1 493 282	93 294	117 542	268 581	500 502	10 438	21 238
Natural resource conservation and development													
Agriculture													
1986	184 946	-	-	260	-	-	26 166	6 517	20 581	127 487	3 911	-	24
1987	170 102	284	-	259	-	-	27 041	6 792	20 420	111 012	4 261	-	33
1988	124 297	36	-	296	-	-	20 872	7 247	11 875	79 431	4 524	4	12
1989	163 413	-	-	346	3	1 912	22 126	7 864	20 632	105 507	4 995	17	11
1990	156 099	-	-	377	-	2 368	19 771	8 302	20 735	99 351	5 051	3	141
1991	168 376	-	-	373	-	2 645	26 245	7 801	25 811	99 764	5 610	6	121
1992p	155 243	-	-	331	-	56	13 489	7 692	27 113	101 010	5 540	1	11
1993p	156 775	-	-	341	-	17	13 204	7 736	27 271	102 652	5 469	1	84
1994[1]	157 570	-	-	341	-	-	13 460	7 604	27 299	103 244	5 621	1	0

Table A2.13

Local Government Environmental Protection Expenditures, 1986-1994 (concluded)

Year	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
						thousand dollars							
Other resource conservation and development													
1986	153 199	139	181	537	2 090	34 051	73 469	8 162	3 750	17 392	13 104	-	324
1987	196 185	184	190	657	4 730	38 488	108 173	8 868	3 340	9 961	21 421	36	137
1988	225 945	533	148	953	5 273	41 905	119 391	9 888	4 349	8 223	35 204	23	55
1989	252 980	723	-	1 934	4 535	61 826	139 722	9 944	3 371	10 815	19 671	100	339
1990	316 331	789	-	837	4 898	76 782	173 697	11 103	4 050	10 327	33 488	194	166
1991	328 878	818	-	1 060	4 817	84 100	170 408	12 262	8 191	10 157	36 747	186	132
1992P	325 906	806	-	1 501	4 049	69 278	184 919	13 677	7 986	10 061	33 365	206	58
1993P	352 645	747	-	1 517	3 655	93 580	183 793	12 297	7 954	15 344	33 544	156	58
1994[1]	301 805	762	-	1 201	3 587	48 400	183 348	10 786	7 663	11 819	34 021	156	62
Total natural resource conservation and development													
1986	338 145	139	181	797	2 090	34 051	99 635	14 679	24 331	144 879	17 015	-	348
1987	366 287	468	190	916	4 730	38 488	135 214	15 660	23 760	120 973	25 682	36	170
1988	350 242	569	148	1 249	5 273	41 905	140 263	17 135	16 224	87 654	39 728	27	67
1989	416 393	723	-	2 280	4 538	63 738	161 848	17 808	24 003	116 322	24 666	117	350
1990	472 430	789	-	1 214	4 898	79 150	193 468	19 405	24 785	109 678	38 539	197	307
1991	497 254	818	-	1 433	4 817	86 745	196 653	20 063	34 002	109 921	42 357	192	253
1992P	481 149	806	-	1 832	4 049	69 334	198 408	21 369	35 099	111 071	38 905	207	69
1993P	509 420	747	-	1 858	3 655	93 597	196 997	20 033	35 225	117 996	39 013	157	142
1994[1]	459 375	762	-	1 542	3 587	48 400	196 808	18 390	34 962	115 063	39 642	157	62

Notes:
Figures may not add due to rounding.
Fiscal years.
Transfers between municipalities and expenditures for parks are excluded.
1. Data for 1994 are forecasts.
2. Local government expenditures on other environmental services may include expenditures specific to pollution control.
Source:
Statistics Canada, Public Institutions Division.

Table A2.14

Selected Statistics on Population by Province and Territory, Selected Years

	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Total population[1] (thousands)														
1981	a	24 900.0	576.5	124.0	856.4	708.4	6 568.0	8 837.8	1 038.5	978.2	2 303.8	2 836.5	24.1	47.9
1986	a	26 203.8	578.1	128.8	892.1	727.7	6 733.8	9 477.2	1 094.0	1 032.9	2 438.7	3 020.4	24.8	55.4
1991	b	28 120.1	580.3	130.8	917.9	748.5	7 080.6	10 471.5	1 112.5	1 006.3	2 601.3	3 379.8	29.1	61.3
1992	b	28 542.2	583.7	131.6	925.1	753.3	7 154.8	10 645.8	1 118.3	1 008.5	2 649.0	3 479.1	30.3	62.6
1993	b	28 947.0	584.6	133.2	930.4	755.8	7 229.1	10 820.6	1 124.8	1 011.4	2 688.5	3 574.0	30.4	63.7
1994	b	29 251.3	581.7	134.6	935.1	758.4	7 284.0	10 931.4	1 131.2	1 013.6	2 719.0	3 667.9	29.6	64.7
1995	b	29 606.1	575.6	136.2	938.2	760.3	7 329.9	11 103.3	1 138.0	1 016.2	2 748.3	3 764.2	30.1	65.8
2016[2]	c	39 883.4	606.1	160.7	1 067.4	850.7	8 924.9	16 055.6	1 255.5	980.4	4 020.2	5 801.2	52.5	108.4
Average annual growth (percent)														
1981 to 1995	d	1.5	--	0.8	0.7	0.6	0.9	2.0	0.7	0.3	1.5	2.5	1.9	2.9
Total fertility rate[3]														
1981	e	1.70 [4]	..	1.91	1.64	1.71	1.61	1.63	1.86	2.14	1.94	1.71	2.14	3.00
1986	e	1.65	1.55	1.84	1.62	1.59	1.43	1.69	1.89	2.09	1.93	1.72	2.04	3.61
1991	f	1.70	1.44	1.85	1.58	1.54	1.65	1.66	1.97	2.03	1.89	1.67	2.14	2.86
1992	f	1.69	1.40	1.82	1.58	1.53	1.65	1.67	1.91	2.03	1.85	1.65	1.93	2.69
1993	f	1.66	1.31	1.72	1.56	1.50	1.61	1.64	1.95	1.96	1.79	1.61	1.91	2.67
Life expectancy at birth (years)														
1981 - Male	c	72.1	72.1	72.9	71.0	71.2	71.3	72.5	72.3	72.5	72.2	72.9	67.0 [5]	67.0 [5]
Female	c	79.3	78.8	80.5	78.6	79.2	78.9	79.2	78.9	79.9	79.3	79.8	74.9 [5]	74.9 [5]
1986 - Male	c	73.3	72.9	72.9	72.5	72.7	72.2	73.8	73.2	73.8	73.7	74.4	69.8 [5]	69.8 [5]
Female	c	80.2	79.3	80.4	79.5	80.1	79.7	80.0	80.0	80.5	80.3	80.8	77.5 [5]	77.5 [5]
1991 - Male	g	74.6	73.7	73.2	73.7	74.3	73.8	75.0	74.6	75.3	75.1	75.3	74.0	70.3
Female	g	81.0	79.5	80.8	80.3	80.9	80.9	81.0	80.8	81.6	81.2	81.4	76.8	76.2
1992 - Male	f	74.8	74.0	73.6	74.0	74.4	74.0	75.1	74.6	75.4	75.3	75.4	73.0	69.8
Female	f	81.0	79.9	80.7	80.6	80.9	81.0	81.0	80.8	81.7	81.2	81.5	77.5	74.8
1993 - Male	f	74.9	73.8	74.3	74.3	74.4	74.0	75.3	74.6	75.4	75.5	75.4	71.0	69.8
Female	f	81.0	80.3	80.1	80.6	80.6	80.9	81.0	80.7	81.8	81.8	81.4	80.9	74.3
Age-standardized mortality rate (deaths per 1 000 population)														
1981 - Male	f	10.5	10.3	10.0	11.4	10.8	11.0	10.4	10.6	9.5	10.2	9.6	15.5	10.2
Female	f	6.1	6.0	5.4	6.4	6.0	6.1	6.1	6.2	5.6	6.1	5.8	8.9	6.8
1986 - Male	f	9.8	10.1	10.3	10.6	10.4	10.7	9.6	9.9	9.3	9.3	8.8	11.0	10.5
Female	f	5.9	6.4	5.9	6.2	5.9	6.0	5.9	5.9	5.5	5.7	5.5	6.7	6.0
1991 - Male	f	9.1	9.8	10.4	9.6	9.2	9.7	8.9	8.9	8.5	8.6	8.4	10.3	10.0
Female	f	5.4	6.1	5.4	5.6	5.3	5.4	5.5	5.4	5.0	5.2	5.1	6.3	7.9
1992 - Male	f	8.9	9.5	9.4	9.8	9.2	9.3	8.8	8.9	8.1	8.4	8.3	7.4	12.2
Female	f	5.2	6.1	5.4	5.6	5.3	5.3	5.3	5.2	4.7	5.1	5.0	8.7	8.5
1993 - Male	f	8.9	9.8	9.5	9.6	9.1	9.5	8.7	9.1	8.3	8.4	8.4	11.4	12.0
Female	f	5.4	5.8	5.5	5.5	5.5	5.5	5.4	5.4	4.9	5.3	5.1	6.3	9.4
Infant mortality rate (deaths per 1 000 live births)														
1981	f	9.6	9.7	13.2	11.5	10.9	8.5	8.8	11.9	11.8	10.6	10.2	14.9	21.5
1986	f	7.9	8.0	6.7	8.4	8.3	7.1	7.2	9.2	9.0	9.0	8.5	24.8	18.6
1991	f	6.4	7.8	6.9	5.7	6.1	5.9	6.3	6.4	8.2	6.7	6.5	10.6	12.2
1992	f	6.1	7.1	1.6	6.0	6.3	5.4	5.9	6.8	7.3	7.2	6.2	3.8	16.7
1993	f	6.3	7.8	9.1	7.1	7.2	5.7	6.2	7.1	8.1	6.7	5.7	7.9	9.6
Urbanization (percent)														
1981	h	75.7	58.6	57.1	50.7	55.1	77.6	81.7	71.2	58.2	77.2	78.0	64.0	48.1
1986	i	76.5	58.9	38.1	54.0	49.4	77.9	82.1	72.1	61.4	79.4	79.2	64.7	46.4
1991	j	76.6	53.6	39.9	53.5	47.7	77.6	81.8	72.1	63.0	79.8	80.4	58.8	36.7

Table A2.14

Selected Statistics on Population by Province and Territory, Selected Years (concluded)

	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Households (thousands)														
1981	k	8 281.5	148.4	37.7	273.2	214.9	2 172.9	2 969.8	358.0	332.7	758.2	996.6	7.6	11.5
1986	k	8 991.7	159.1	40.7	295.8	231.7	2 357.1	3 221.7	382.3	358.3	836.1	1 087.1	8.0	13.8
1991	k	10 018.3	174.5	44.5	324.4	253.7	2 634.3	3 638.4	405.1	363.1	910.4	1 243.9	9.9	16.1
1992[6]	l	10 056.0	177.0	46.0	329.0	256.0	2 656.0	3 647.0	396.0	359.0	912.0	1 278.0	..	..
1993[6]	l	10 247.0	182.0	47.0	336.0	256.0	2 688.0	3 765.0	387.0	361.0	923.0	1 302.0	..	..
1994[6]	l	10 387.0	183.0	48.0	332.0	255.0	2 720.0	3 820.0	397.0	361.0	928.0	1 344.0	..	..
1995[6]	l	11 244.0	194.0	50.0	357.0	286.0	2 937.0	4 143.0	419.0	385.0	1 009.0	1 464.0	..	..
Expenditures on education[7] (million dollars)														
1980-81	m	22 201.6	462.0	92.2	707.0	530.5	6 754.0	7 497.0	849.3	871.0	1 956.8	2 224.4	31.7	66.9
1985-86	n	34 564.1	741.3	150.0	1 134.0	873.2	9 442.7	12 073.4	1 425.3	1 382.0	3 603.8	3 246.0	45.8	131.3
1990-91	n	48 679.6	1 038.3	193.8	1 475.2	1 205.6	11 969.1	18 471.7	1 959.9	1 757.1	4 565.1	5 279.6	79.1	219.1
1991-92	n	53 075.7	1 083.3	209.9	1 532.0	1 274.2	12 974.6	20 571.7	2 048.5	1 816.1	4 802.4	5 956.5	89.0	247.7
1992-93	n	55 760.3	1 161.8	220.0	1 563.1	1 365.5	13 796.9	21 221.1	2 100.4	1 826.3	5 130.7	6 336.7	112.9	326.7
1993-94[p]	o	56 398.3	1 291.8	224.1	1 623.6	1 375.7	13 790.5	21 331.6	2 101.4	1 807.3	5 234.5	6 523.5	105.8	342.6
1994-95[e]	o	57 124.2	1 247.9	219.2	1 625.5	1 346.2	14 193.6	21 280.0	2 112.5	1 855.6	5 199.3	6 917.3	108.1	375.5
Land area (thousand km^2)														
	p	9 215.4	371.7	5.7	52.8	72.1	1 356.8	891.2	548.4	570.7	644.4	929.7	479.0	3 293.0
Population density (persons per km^2)														
1981	d	2.7	1.6	21.9	16.2	9.8	4.8	9.9	1.9	1.7	3.6	3.1	0.1	--
1986	d	2.8	1.6	22.8	16.9	10.1	5.0	10.6	2.0	1.8	3.8	3.2	0.1	--
1991	d	3.1	1.6	23.1	17.4	10.4	5.2	11.8	2.0	1.8	4.0	3.6	0.1	--
1993	d	3.1	1.6	23.5	17.6	10.5	5.3	12.1	2.1	1.8	4.2	3.8	0.1	--
1994	d	3.2	1.6	23.8	17.7	10.5	5.4	12.3	2.1	1.8	4.2	3.9	0.1	--
1995	d	3.2	1.5	24.1	17.8	10.5	5.4	12.5	2.1	1.8	4.3	4.0	0.1	--
2016	d	4.3	1.6	28.4	20.2	11.8	6.6	18.0	2.3	1.7	6.2	6.2	0.1	--

Notes:

Figures may not add due to rounding.

1. Total population as of July 1st of each year.
2. Projection 3 - Medium growth.
3. The total fertility rate is based on the age-specific fertility rates for a particular year and refers to the number of children that each woman would, on average, bear in her lifetime. A generation would be replaced if, on average, each woman bore 2.1 children.
4. Excluding Newfoundland.
5. The Yukon and Northwest Territories are combined, their estimates are subject to random fluctuations due to small numbers.
6. The total number of households for 1992 to 1995 are estimated figures. Estimates are unavailable for the Yukon and Northwest Territories.
7. The sum of the expenditures on education of the 12 provinces and territories is not equal to Canada's total because the latter also includes Canada's spending on education in foreign countries and undistributed expenditures.

Sources:

a. Statistics Canada, *Annual Demographic Statistics*, Catalogue No. 91-213, Ottawa, 1994.
b. Statistics Canada, *Quarterly Demographic Statistics*, Catalogue No. 91-002, Vol. 9, No. 2, Ottawa, 1995.
c. Statistics Canada, *Population Projections for Canada, Provinces and Territories, 1993-2016*, Catalogue No. 91-520, Ottawa, 1994.
d. Statistics Canada, National Accounts and Environment Division.
e. Statistics Canada, *Selected Birth and Fertility Statistics, Canada, 1921-1990*, Catalogue No. 82-553, Ottawa, 1993.
f. Statistics Canada, *Births and Deaths, 1993*, Catalogue No. 84-210-XPB, Ottawa, 1996.
g. Statistics Canada, *Births, 1992*, Catalogue No. 84-210, Ottawa, 1995.
h. Statistics Canada, *Population - Geographic Distributions*, Catalogue No. 93-905, Vol. 2, Ottawa, 1982.
i. Statistics Canada, *Urban and Rural Areas, Canada, Provinces and Territories - Part 1*, Catalogue No. 94-129, Ottawa, 1988.
j. Statistics Canada, *Profile of Urban and Rural Areas - Part B*, Catalogue No. 93-340, Ottawa, 1994.
k. Statistics Canada, *Dwellings and Households*, Catalogue No. 93-311, Ottawa, 1992.
l. Statistics Canada, *Household facilities by income and other characteristics*, Catalogue No. 13-218, Ottawa, various issues.
m. Statistics Canada, *Financial Statistics of Education 1984-85*, Catalogue No. 81-208, Ottawa, 1989.
n. Statistics Canada, *Education in Canada*, Catalogue No. 81-229, Ottawa, various issues.
o. Statistics Canada, *Education Quarterly Review*, Catalogue No. 81-003, Vol. 2, No. 3, Ottawa, 1995.
p. Statistics Canada, *Canada Year Book, 1994*, Catalogue No. 11-402E, Ottawa, 1994.

Table A2.15

Selected Statistics on the Economy by Province and Territory, 1981-1995

	Source	Canada	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
Gross Domestic Product[1] (million 1986 dollars)														
1981	a	440 127	6 247	1 309	10 585	8 534	103 506	167 431	15 667	15 053	52 786	54 365	456	1 149
1986	a	505 666	6 938	1 516	13 155	10 307	116 622	205 643	18 562	17 364	56 617	55 527	599	1 470
1991	a	555 052	7 789	1 710	14 136	11 111	126 156	222 106	18 816	19 269	64 231	66 349	799	1 779
1992	a	559 305	7 824	1 749	14 407	11 528	126 510	224 330	19 039	18 301	64 434	67 918	862	1 659
1993	a	571 722	7 952	1 771	14 605	12 001	129 621	226 954	19 210	18 865	68 130	69 522	678	1 730
1994	a	597 936	8 148	1 881	14 793	12 247	134 046	239 622	19 763	19 410	72 157	72 872	673	1 756
1995	a	611 300	8 138	1 975	14 886	12 393	136 407	246 990	20 252	19 512	73 381	74 227	746	1 806
GDP per capita (thousand 1986 dollars per person)														
1981	b	17 676	10 845	10 556	12 366	12 054	15 757	18 942	15 093	15 392	22 911	19 170	19 000	23 938
1986	b	19 297	12 003	11 752	14 748	14 158	17 318	21 699	16 967	16 809	23 213	18 386	23 960	26 727
1991	b	19 739	13 429	13 053	15 399	14 834	17 816	21 212	16 906	19 154	24 695	19 630	27 552	29 164
1992	b	19 596	13 420	13 250	15 575	15 309	17 667	21 074	17 030	18 156	24 342	19 534	28 733	26 333
1993	b	19 751	13 616	13 316	15 704	15 874	17 906	20 985	17 091	18 660	25 365	19 447	22 600	27 031
1994	b	20 442	14 024	13 933	15 838	16 157	18 395	21 913	17 489	19 180	26 577	19 862	22 433	27 015
1995	b	20 648	14 153	14 522	15 870	16 307	18 599	22 251	17 796	19 205	26 713	19 710	24 867	27 364
Average annual real GDP growth 1986-95: Goods producing industries (1986$) (percent)														
Primary	c	2.6	-2.1	1.5	0.3	3.0	2.5	0.5	-1.1	1.2	5.0	2.8	2.8	-3.3
Manufacturing	c	2.0	-2.2	6.9	-0.4	1.6	2.0	1.8	1.1	1.4	6.4	1.5	11.6	1.7
Other goods producing industries	c	0.3	0.2	2.9	-1.1	0.3	0.1	-0.7	0.2	-1.0	1.0	4.6	2.3	-1.2
GDP distribution at factor cost by industry (1992): Goods producing industries (percent)														
Primary	c	17.3	21.2	32.1	19.7	21.5	8.6	6.9	24.8	56.4	49.1	20.4	69.4	61.4
Manufacturing	c	51.9	29.1	34.7	44.6	40.5	58.6	65.5	42.8	16.7	22.9	40.4	2.3	1.6
Other goods producing industries	c	30.8	49.7	33.2	35.7	38.0	32.8	27.6	32.4	26.9	28.0	39.2	28.3	37.0
Personal income per capita (1986 dollars per person)														
1981	b	15 597	10 679	10 296	12 284	11 564	14 656	16 361	14 079	14 829	17 513	16 927	..	..
1986	b	16 305	11 590	12 279	13 737	12 841	15 339	17 850	14 957	14 700	17 069	16 184	17 000	14 345
1991	b	17 075	13 910	13 388	14 675	13 874	16 138	18 394	15 298	14 221	17 581	17 911	19 870	17 099
1992	b	17 006	14 039	13 600	14 793	14 229	16 044	18 273	15 521	14 305	17 507	17 700	20 390	16 918
1993	b	16 780	13 947	13 828	14 826	14 250	15 881	17 845	15 165	14 240	17 632	17 410	19 714	18 451
1994	b	16 928	14 001	13 712	14 641	14 192	16 263	18 019	15 333	13 962	17 490	17 458	19 507	17 282
1995	b	16 918	14 021	14 504	14 657	14 296	16 340	17 852	15 331	14 303	17 473	17 473	19 816	17 208
Passenger automobiles[2] (thousands)														
1981	d	10 199	142	49	350	252	2 379	3 831	460	392	1 216	1 116	7	6
1986	d	11 477	176	56	337	286	2 614	4 244	528	389	1 296	1 527	8	17
1991	d	13 061	202	64	426	312	2 978	4 847	544	416	1 424	1 807	20	20
1992	d	13 322	207	62	422	318	3 031	4 925	551	441	1 482	1 852	9	20
1993	d	13 478	207	65	429	324	3 070	5 002	551	414	1 507	1 879	10	20
1994	d	13 639	216	65	392	328	3 107	5 069	557	421	1 546	1 916	11	10
Passenger automobiles per capita (vehicles per thousand persons)														
1981	b	409.6	245.6	391.6	409.2	355.0	362.2	433.5	443.4	400.5	528.0	393.4	278.1	128.3
1986	b	438.0	305.1	436.5	377.9	393.1	388.2	447.8	482.2	376.3	531.3	505.5	302.8	309.1
1991	b	464.5	348.3	486.9	464.1	417.3	420.6	462.8	489.3	413.8	547.5	534.6	671.0	331.2
1992	b	466.8	354.7	474.5	456.6	421.8	423.7	462.7	493.1	437.3	559.6	532.4	298.1	322.0
1993	b	465.6	354.5	484.8	461.4	429.1	424.7	462.2	489.9	409.5	560.6	525.7	319.9	309.1
1994	b	466.3	371.9	484.6	419.4	432.6	426.6	463.7	492.2	415.2	568.6	522.4	382.7	148.1
Gasoline net sales[3] **for automotive purposes** (million litres)														
1981	e	30 782.5	587.1	171.3	1 141.1	1 070.8	8 104.6	12 610.2	1 323.7	1 460.3	.. [4]	4 224.7	57.9	30.8
1986	e	25 859.2	521.9	165.1	1 039.8	914.1	6 578.4	11 715.6	1 296.2	.. [4]	.. [4]	3 551.8	54.6	21.7
1991	e	31 209.1	573.6	168.8	1 065.9	904.5	6 823.6	11 887.3	1 250.2	1 169.7	3 746.7	3 527.6	59.0	32.1
1992	e	31 786.8	578.3	172.1	1 082.1	929.8	6 868.3	11 982.5	1 244.5	1 445.5	3 718.7	3 666.9	65.4	32.7
1993	e	32 563.4	585.1	174.0	1 085.3	961.1	7 037.7	12 255.2	1 253.9	1 373.5	3 873.7	3 869.5	61.3	33.1
1994	e	33 297.0	591.5	182.3	1 104.5	1 001.0	7 199.9	12 530.0	1 278.4	1 297.6	3 924.6	4 083.0	66.4	37.8
Gasoline net sales[3] **per capita** (litres per person)														
1981	b	1 236.2	1 018.4	1 381.7	1 332.5	1 511.6	1 233.9	1 426.8	1 274.6	1 492.8	..	1 489.4	2 401.4	643.1
1986	b	986.9	902.8	1 281.9	1 165.6	1 256.2	976.9	1 236.2	1 184.8	..	..	1 175.9	2 201.2	391.3
1991	b	1 109.8	988.5	1 290.2	1 161.3	1 208.4	963.7	1 135.2	1 123.8	1 162.4	1 440.3	1 043.7	2 029.1	524.1
1992	b	1 113.7	990.7	1 308.1	1 169.8	1 234.3	960.0	1 125.6	1 112.8	1 433.3	1 403.8	1 054.0	2 157.0	522.5
1993	b	1 124.9	1 000.8	1 306.4	1 166.5	1 271.7	973.5	1 132.6	1 114.8	1 358.0	1 440.8	1 082.7	2 015.7	520.0
1994	b	1 138.3	1 016.8	1 354.8	1 181.1	1 319.9	988.5	1 146.2	1 130.1	1 280.2	1 443.4	1 113.2	2 242.3	584.1

Notes:

Figures may not add due to rounding.

1. The sum of the GDPs of the 12 provinces and territories is not equal to Canada's total GDP because the latter also includes wages and salaries of public servants working abroad.
2. Includes taxis and for-hire cars.
3. Net sales refer to those sales of gasoline, diesel and liquefied petroleum gas on which taxes were remitted at road-use rates.
4. Net sales statistics are not available because the road tax was removed in both Alberta (April 1978) and Saskatchewan (April 1982).

Sources:

a. Statistics Canada, *Provincial Economic Accounts: Annual Estimates, 1961-1995*, Catalogue No. 13-213-XDB, Ottawa, 1996.
b. Statistics Canada, National Accounts and Environment Division.
c. Statistics Canada, *Provincial Gross Domestic Product by Industry, 1984-1995*, Catalogue No. 15-203-XPB, Ottawa, 1996.
d. Statistics Canada, *Road Motor Vehicles, Registrations*, Catalogue No. 53-219, Ottawa, various issues.
e. Statistics Canada, *Road Motor Vehicles Fuel Sales*, Catalogue No. 53-218, Ottawa, various issues.

ORDER FORM

National Accounts and Environment Division

IAIL TO: **Iarketing Division** **'ublication Sales** **;tatistics Canada** **)ttawa, Ontario, K1A 0T6** *Please print*) ;ompany ______)epartment ______ ttention ______ ddress ______ ;ity ______ Province ______ 'ostal Code ______ Tel. ______ Fax ______	**FAX TO: (613) 951-1584** A Fax will be treated as an original order. Please do not send confirmation.

METHOD OF PAYMENT:

☐ Purchase Order Number (*please enclose*) ______

Authorized signature ______

☐ Payment enclosed $ ______

Please charge my: ☐ MasterCard ☐ VISA

Card Number

Expiry Date

Signature ______

;atalogue Iumber	Title	Frequency/ Release Date	Annual Subscription or Book Price Canada $	United States US$	Other Countries US$	Qty	Total $
	PUBLICATIONS						
11-509-XPE	Human Activity and the Environment, 1994	Occasional 06/94	35.00	42.00	49.00		
11-526-XPB	Households and the Environment, 1994	Occasional 04/95	27.00	32.00	37.00		
11-527-XPE	Databases for Environmental Analysis: Government of Canada	Occasional 12/92	55.00	66.00	77.00		
11-529-XPE	Databases for Environmental Analysis: Provincial and Territorial Governments	Occasional 08/94	75.00	90.00	105.00		
11-528-XPE	Environmental Perspectives: Studies and Statistics 1993	Occasional 03/93	25.00	30.00	35.00		
11-528-XPE, No. 2	Environmental Perspectives: Studies and Statistics	Occasional 06/95	35.00	42.00	49.00		
11-528-XPE, No. 3	Environmental Perspectives: Studies and Statistics	Occasional 06/96	35.00	42.00	49.00		
	DISKETTES						
11-509-XDE	Human Activity and the Environment, 1994 (Sold only to purchasers of publication 11-509-XPE)	Occasional 06/94	15.00	18.00	21.00		
11-532-XDE	Databases for Environmental Analysis: Federal, Provincial and Territorial Governments	Occasional 12/95	75.00	90.00	105.00		

	SUBTOTAL	
Canadian customers add 7% Goods and Services Tax. (GST No. R121491807).	**GST (7%)**	
Please note that discounts are applied to the price of the publication and not to the total amount which might include special shipping and handling charges and the GST.	**GRAND TOTAL**	

Cheque or money order should be made payable to the *Receiver General for Canada - Publications*. Canadian clients pay in Canadian funds. Clients from the United States and other countries pay total amount in US funds drawn on a US bank.

Order completed by: Date:

Subscriptions will begin with the next issue.

For faster service **1-800-267-6677** **VISA and MasterCard Accounts**

PF 03551 06/96

BON DE COMMANDE

Division des comptes nationaux et de l'environnement

ENVOYEZ À:
Division du marketing
Vente des publications
Statistique Canada
Ottawa (Ontario) K1A 0T6

TÉLÉCOPIEZ AU: (613) 951-1584
Le bon télécopié tient lieu de commande originale. Veuillez ne pas envoyer de confirmation.

(*Veuillez écrire en caractères d'imprimerie s.v.p.*)

Compagnie ______

Service ______

À l'attention de ______

Adresse ______

Ville ______ Province ______

Code postal ______ Tél. ______ Télécopieur ______

MODALITÉS DE PAIEMENT:

☐ N° du bon de commande (*inclure s.v.p.*) ______

Signature autorisée ______

☐ Paiement inclus $ ______

Veuillez débiter mon compte: ☐ MasterCard ☐ VISA

N° de carte ______

Date d'expiration ______

Signature ______

Numéro au catalogue	Titre	Fréquence de parution/ Date de parution	Abonnement annuel ou prix de la publication Canada $	États-Unis $US	Autres pays $US	Qté	Total $
	PUBLICATIONS						
11-509-XPF	L'activité humaine et l'environnement, 1994	Hors série 06/94	35,00	42,00	49,00		
11-526-XPB	Les ménages et l'environnement, 1994	Hors série 04/95	27,00	32,00	37,00		
11-527-XPF	Bases de données pour l'analyse environnementale: gouvernement du Canada	Hors série 12/92	55,00	66,00	77,00		
11-529-XPF	Bases de données pour l'analyse environnementale: gouvernement provinciaux et territoriaux	Hors série 08/94	75,00	90,00	105,00		
11-528-XPF	Perspectives sur l'environnement, 1993: Études et statistiques	Hors série 03/93	25,00	30,00	35,00		
11-528-XPF, n° 2	Perspectives sur l'environnement: Études et statistiques	Hors série 06/95	35,00	42,00	49,00		
11-528-XPF, n° 3	Perspectives sur l'environnement: Études et statistiques	Hors série 06/96	35,00	42,00	49,00		
	DISQUETTES						
11-509-XDF	L'activité humaine et l'environnement, 1994 (Vendue seulement aux acheteurs de la publication 11-509-XPF)	Hors série 06/94	15,00	18,00	21,00		
11-532-XDF	Bases de données pour l'analyse environnementale: gouvernements fédéral, provinciaux et territoriaux	Hors série 12/95	75,00	90,00	105,00		

	TOTAL	
Les clients canadiens ajoutent la taxe de 7 % sur les produits et services. (TPS N° R121491807)	**TPS (7%)**	
Veuillez noter que les réductions s'appliquent au prix des publications et non au total général; ce dernier pouvant inclure des frais de port et de manutention particuliers et la TPS.	**TOTAL GÉNÉRAL**	

Le chèque ou mandat-poste doit être établi à l'ordre du *Receveur général du Canada - Publications.* Les clients canadiens paient en dollars canadiens. Les clients à l'étranger paient le montant total en dollars US tirés sur une banque américaine.

Commande remplie par: Date:

Tout abonnement débute avec le prochain numéro à paraître.

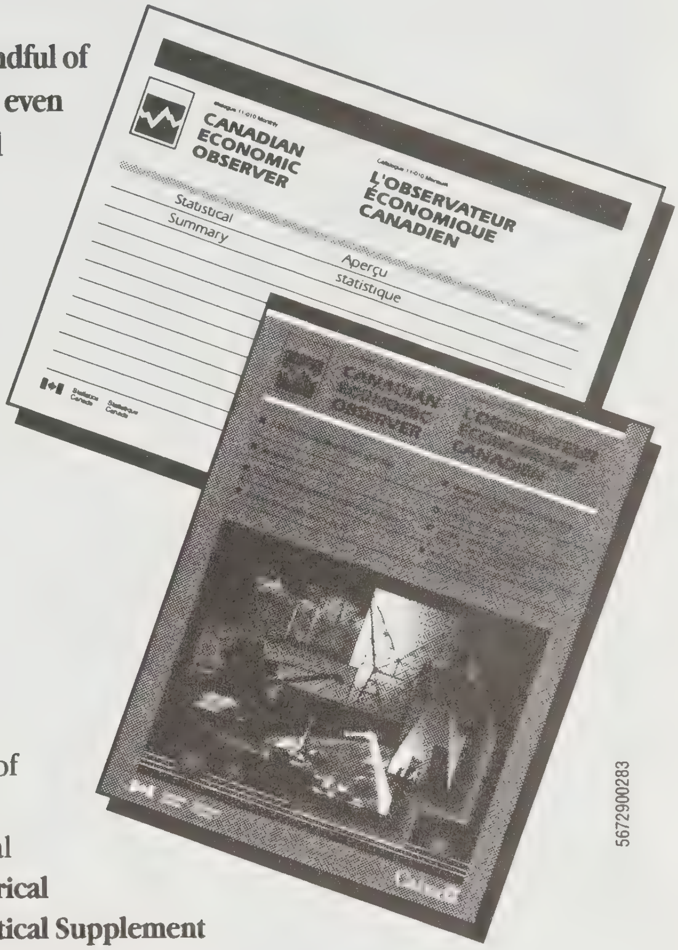
Pour un service plus rapide, composez 1-800-267-6677 **Comptes VISA et MasterCard**

PF 03551 03/96

Are you getting your information on the Canadian economy "first-hand"?

Chances are, you spend hours reading several newspapers and a handful of magazines trying to get the whole economic picture – only to spend even more time weeding out fiction from fact! Wouldn't it be a great deal more convenient (and much more effective) to go straight to the source?

Join the thousands of successful Canadian decision-makers who turn to Statistic Canada's *Canadian Economic Observer* for their monthly briefing. Loaded with first-hand information, collectively published nowhere else, CEO is a quick, concise and panoramic overview of the Canadian economy. Its reliability and completeness are without equal.



A single source

Consultations with our many readers – financial analysts, planners, economists and business leaders – have contributed to CEO's present, widely-acclaimed, two-part format. The **Analysis Section** includes thought-provoking commentary on current economic conditions, issues, trends and developments. The **Statistical Summary** contains the complete range of hard numbers on critical economic indicators: markets, prices, trade, demographics, unemployment and more.

More practical, straightforward and user-friendly than ever before, the ***Canadian Economic Observer*** gives you more than 150 pages of in-depth information in one indispensable source.

Why purchase CEO?

As a subscriber, you'll be directly connected to Statistics Canada's economic analysts – names and phone numbers are listed with articles and features. You'll also receive a copy of CEO's annual **Historical Statistical Supplement** – at no additional cost.

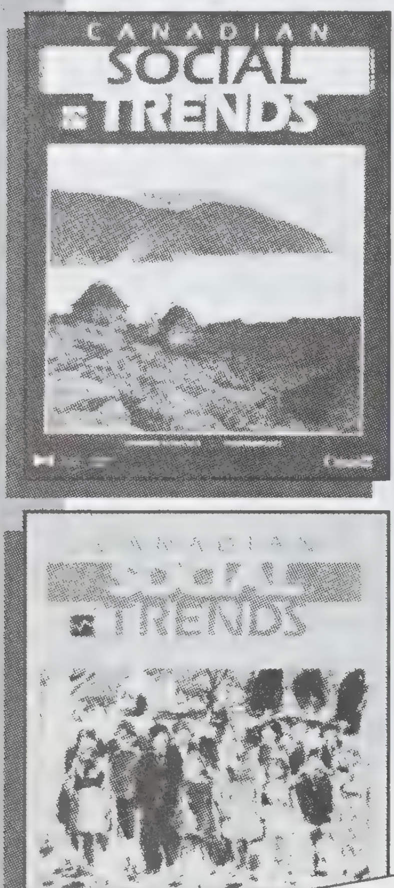
So why wait for others to publish Statistics Canada's data second-hand when you can have it straight from the source? Order your subscription to the ***Canadian Economic Observer*** today.

5672900283

The ***Canadian Economic Observer*** (catalogue no. 10-2300XPB) is $220 (plus GST and applicable PST) annually in Canada, US$260 in the United States and US$310 in other countries. Highlights of the ***Canadian Composite Leading Indicator*** (catalogue no. 11F0008XFE) are available by fax – the same day of release – for $70 annually in Canada and US$70 in the United States.

To order, write to: Statistics Canada, Operations and Integration Division, Circulation Management, 120 Parkdale Avenue, Ottawa, Ontario, K1A 0T6 or contact the nearest Statistics Canada Reference Centre listed in this publication. If more convenient, fax your order to 1-613-951-1584 or call toll-free 1-800-267-6677 and use your VISA or MasterCard. Via Internet: order@statcan.ca

Don't let the changing world take *you* by surprise!



An aging population. Lone-parent families. A diverse labour force. Do you know how today's social changes will affect your future ... your organization ... and your family?

Keep pace with the dramatic shifts in Canada's evolving social fabric with Statistics Canada's best-selling quarterly, ***Canadian Social Trends.*** With vast and varied reports on major changes in key social issues and trends, this periodical incorporates findings from over 50 national surveys.

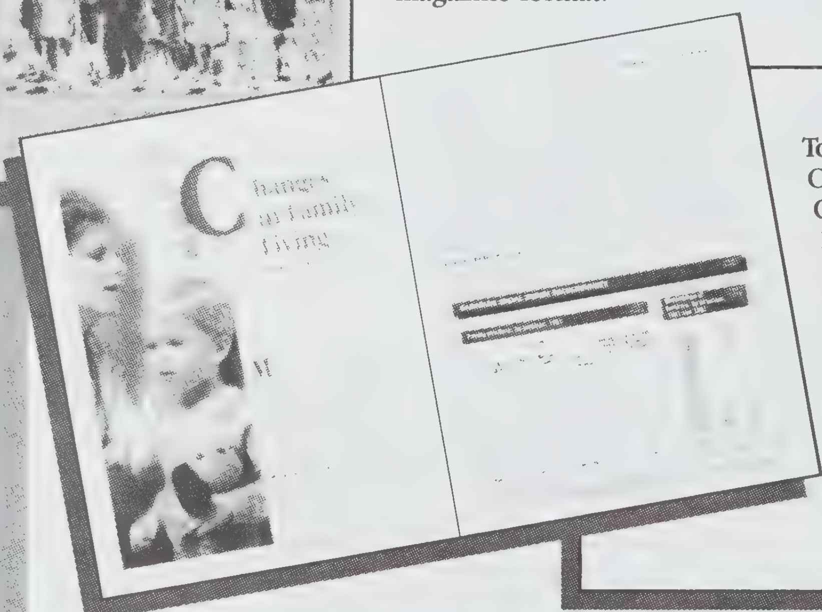
Written by some of Canada's leading-edge social analysts, ***Canadian Social Trends*** combines painstaking research with dynamic prose on topics like **ethnic diversity, low-income families, time-crunch stress, violent crime** and much more — all in a colourful, easy-to-read, magazine format.

A lasting record of changing times!

Join the thousands of business and policy analysts, social-science professionals, and academics who trust ***Canadian Social Trends*** to demystify the causes and consequences of change in Canadian society. Don't miss a single issue — subscribe today.

Canadian Social Trends

(catalogue number 11-0080XPE) is $34 (plus GST and applicable PST) annually in Canada, US$41 in the United States and US$48 in other countries.



To order, write to Statistics Canada, Operations and Integration Division, Circulation Management, 120 Parkdale Ave., Ottawa, Ontario, K1A 0T6 or contact the nearest Statistics Canada Reference Centre listed in this publication.

If more convenient, fax your order to 1-613-951-1584 or call toll-free 1-800-267-6677 and use your VISA or MasterCard.
Via Internet: order@statcan.ca

56729000282

2273

ISBN 0-660-16515-5

9 780660 165158

11-528-XPE96001